(1/63)

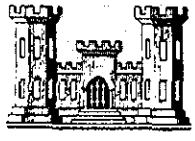
HURRICANE SURVEY

INTERIM REPORT

STRATFORD

CONNECTICUT

APPENDICES



U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.

22 March 1963

HURRICANE SURVEY

STRATFORD, CONN.

APPENDICES

GLOSSARY

APPENDIX A - HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

APPENDIX B - HYDROLOGY AND HYDRAULICS

APPENDIX C - FLOOD LOSSES AND BENEFITS

APPENDIX D - DESIGN STUDIES AND COST ESTIMATES

APPENDIX E - LETTERS OF COMMENT

GLOSSARY

HURRICANE SURGE: the mass of water causing an increase in the elevation of the water surface above predicted astronomical tide at the time of a hurricane; it includes wind setup; sometimes the maximum increase in elevation is referred to as the surge.

HURRICANE TIDE: the rise and fall of the water surface during a hurricane, exclusive of wave action.

KNOT: a velocity equal to one nautical mile (6080.2 feet) per hour (about 1.15 statute miles per hour).

OVERTOPPING: that portion of the wave runup which goes over the top of a protective structure.

PONDING: the storage of water behind a dike or wall from local runoff and/or overtopping by waves.

POOL BUILDUP: the increase in elevation of water surface behind a structure due to runoff and/or overtopping by waves.

RUNUP: the rush of water up the face of a structure on the breaking of a wave. The height of runup is measured from the stillwater level.

SIGNIFICANT WAVE: a statistical term denoting waves with the average height and period of the one-third highest waves of a given wave train.

SPRING TIDE: a tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.

STANDARD PROJECT HURRICANE: a storm that may be expected from the most severe combination of meteorologic conditions that are considered reasonably characteristic of the region involved, excluding rare combinations.

STILLWATER LEVEL: the elevation of the water surface if all wave action were to cease.

STORM SURGE: same as "hurricane surge".

WAVE HEIGHT: the vertical distance between the crest and the preceding trough.

WAVE TRAIN: a series of waves from the same direction.

WIND SETUP: the vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water.

APPENDIX A

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

APPENDIX A

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

TABLE OF CONTENTS

Paragraph	Title	Page
A-1	GENERAL	A-1
A-2	SUMMARY OF HURRICANE AND STORM OCCURRENCES	A-2
A-3	DESCRIPTIONS	A-11
A-4	HURRICANE TRACKS	A-24

Number	TABLE	
A-1	HISTORICAL HURRICANES	A-3

	PLATE	
A-1	TRACKS OF SELECTED HURRICANES	

APPENDIX A

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

A-1. GENERAL

In order to determine the possibility of future hurricane occurrences, a review has been made of historical data on past hurricanes that have struck or threatened the coast of Connecticut. Since the eastern entrance of Long Island Sound lies in the path of hurricanes moving into New England from the south, the Connecticut coastline, on the north shore of the Sound, has frequently been subject to tidal flooding from hurricane surges moving west up the Sound. The records indicate that the coast of Connecticut, including Stratford, has experienced or has been threatened by hurricane tidal flooding upon 65 occasions since 1769. The greater number of these hurricanes, owing to the locations of their paths, did not cause tidal flooding along the Connecticut shore. However, they did present a potential threat of such flooding. Of the 9 hurricanes that have caused severe tidal flooding, the 5 greatest, as far as can be determined from existing records, are listed below in their estimated order of magnitude.

21 September 1938
24 August 1893
31 August 1954
15 September 1815
14 September 1944

In recent years, the hurricanes that caused tidal flooding along the coasts of Rhode Island and southern Massachusetts also caused flooding along the Connecticut coast. Prior to 19 October 1770, five hurricanes are known to have affected the coastal areas of Massachusetts and Rhode Island. The two earliest of these storms, namely those of 15 August 1635 and 3 August 1638, caused extensive tidal flooding, probably the greatest ever experienced in New England during the past 200 to 300 years. Since there was very little development along the Connecticut shore until after 1638, there are no available records to indicate that these storms affected Long Island Sound. It is reasonable to assume, however, that they did cause inundation of the coastal lowlands of Connecticut.

Since the extent of flood damages is relative to the degree of development in the areas flooded, the early great hurricanes were not as damaging as those of the present century. As a matter of fact, the two earliest hurricanes of record in New England, which according to history must have been very severe, occurred prior to the settlement of Stratford and other cities and towns along the Connecticut coast.

The recurrence of these two hurricanes under present conditions would cause extensive damages, possibly in excess of the damages sustained in September 1938.

A-2. SUMMARY OF HURRICANE AND STORM OCCURRENCES

A summary has been prepared, see Table A-1, which lists all hurricanes known to have directly affected the coast of Connecticut, and also, all hurricanes known to have threatened the area. In the latter case, a slight change in meteorological conditions could have caused any of these hurricanes to follow a course more critical to Long Island Sound, thereby subjecting the Connecticut coastal area to tidal flooding. The following classifications indicate the effect of the recorded hurricane occurrences on the Connecticut coast:

Type "A": Hurricanes causing severe tidal flooding.
Type "B": Hurricanes causing damage from wind and rainfall (usually accompanied by high seas and moderate tidal flooding).
Type "C": Hurricanes threatening the area.

Of the 65 hurricanes of record, listed in Table A-1, that have either caused or threatened damage along the Connecticut coast since 1769, 9 are of the type "A", 25 of type "B" and the remaining 31 of type "C". Forty-four of the listed hurricane experiences (3 type "A", 15 type "B", and 26 type "C",)have occurred during the period from 1901 to 1961,inclusive. The fact that there is a record of 44 hurricanes in this 61-year period, as compared with 21 in the 131-year period from 1770 to 1900,inclusive, is not considered indicative of a greater trend in hurricane activity in recent years but to a lack of records and information on storms prior to 1900.

TABLE A-1

HISTORICAL HURRICANES

Connecticut Coast

Date of Hurricane	Category (1)	Source of Data	Remarks
1635, Aug. 15	A	(2)(3)	Great tidal surge along coast of R.I. Effect on Conn. coast not known.
1638, Aug. 3	A	(3)	Historical account indicates greatest tidal flooding ever experienced along Mass. and R.I. coast. Effect on Conn. coast not known.
1723, Oct. 30	A	(3)	Very high tide in R.I.; considerable damage. Effect on Conn. coast not known.
1757, June 30	C	(2)	Atlantic Coast hurricane, Florida to Boston, Mass. Effect on Conn. coast not known.
1761, Oct. 24	A	(3)	Very high tides in Narragansett Bay, R.I. Damage from wind and water. Effect on Conn. coast not known.
1770, Oct. 19-20	A	(3)	A violent storm; immense loss of life and property along the coast. Report of boat damage at New London, Conn,
1773, Aug. 19	C	(2)(3)	Passed near Boston, Mass. "abundant showers" in Conn.
1787, Sept. 19	B	(3)	Reports of damage at Stamford and Norwalk, Conn.
1788, Aug. 19	B	(2)(3)	Affected western New England; much wind and rain damage in Conn. and Mass.

(Footnotes are at end of table)

TABLE A-1 (cont'd)

Date of Hurricane	(1) Category	Source of Data	Remarks
1804, Sept. 8-9	C	(2)	Severe storm passed over Cape Cod, traveling northeast. No account of damage in Conn.
1804, Oct. 9-10	B	(2)(3)	Reports of minor wind and rain damage.
1815, Sept. 22-23	A	(2)(3)	Very high tide; considerable damage along Conn. coast from tidal flooding.
1821, Sept. 3	A	(2)(3)	Wind damage to boats and homes. Tidal flood damage at New London, Conn.
1829, July 24	C	(2)(3)	Reported to have been felt in Boston, Mass. No accounts of damage in Conn.
1841, Oct. 2-4	B	(2)(3)	Violent winds and heavy rain; reports of wind damage at Hartford, Conn.
1854, Sept. 10-11	C	(2)(3)	Severe in southern states; passed over New England, near Boston. Heavy rain and high winds at New Haven, Conn.
1866, Oct. 29-30	B	(2)(3)	Reports of wind damage.
1869, Sept. 8	A	(2)(3)	Tidal-flooding at Mystic, Conn.
1877, Oct. 4-5	C	(2)(3)	Path was south of Long Island and Nantucket. No accounts of damage in Conn.
1878, Oct. 22-23	A	(2)(3)	Reports of wind damage at Bridgeport; very high tide at Greenwich, Conn.
1878, Dec. 10	B	(3)	Reports of wind, rain, and minor tidal-flooding along the coast.

TABLE A-1 (cont'd)

Date of Hurricane	(1) Category	Source of Data	Remarks
1879, Aug. 18	B	(2)(3)	Passed over Cape Cod. Damage to crops from wind and rain at Stamford, Conn.
1889, Sept. 10	B	(2)(3)	Streets in Stamford flooded by heavy rain. Very high tide at Greenwich, Conn.
1893, Aug. 23-24	A	(2)(3)	Wind, rain, and high tide caused damage along Conn. coast.
1893, Aug. 29	B	(2)(3)	Storm passed west of New York City, crossed central Maine, moving northeast. Reports of high tides and heavy surf along Conn. coast.
1896, Sept. 9-10	B	(2)(3)	Torrential rain and hurricane winds along Conn. coast.
1901, Sept. 19	C	(2)(4)	Passed south and east of Cape Cod.
1902, June 16-17	C	(2)(3)(4)	Path crossed Buzzards Bay and Cape Cod, moving northeast. Strong winds over L.I. Sound.
1902, June 29-30	C	(2)	Center passed over Conn. and southern R.I., traveling southeast; no account of damage.
1902, Oct. 12	C	(2)(3)(4)	Path south of Long Island and Nantucket, moving east. Heavy rain and high wind at New Haven, Conn.
1903, Sept. 16	B	(2)(3)(4)	Storm crossed northeastern Pa., moving northwest. High winds and high water along Conn. Coast

TABLE A-1 (cont'd)

Date of Hurricane	(1) Category	Source of Data	Remarks
1904, Sept. 15	B	(2)(3)	Center passed over northeastern Conn., moving northeast. Reports of rain and wind damage.
1904, Nov. 13	B	(2)(4)	Passed south of Nantucket, moving northeast. Reports of wind damage.
1911, Sept. 1	C	(2)	Passed south of Cape Cod. No accounts of damage in Conn.
1912, Sept. 16	C	(2)	Followed easterly path across southern New England.
1916, July 21	C	(2)(4)	Passed off east end of Cape Cod, heading northeast.
1920, Sept. 30 - Oct. 1	B	(2)(3)(4)	Storm passed just west of New York, heading north. Reports of damage from high tides along Conn. coast.
1923, Oct. 19	C	(2)(4)	Passed near Boston, moving northwest. Storm of slight energy.
1924, Aug. 26	B	(2)(3)	Crossed tip of Cape Cod, moving northeast. Some damage from strong winds.
1929, Oct. 2	B	(2)(4)	Moved northeast, passing over eastern New York and northwestern Vermont. High tides caused damage along Conn. coast.

TABLE A-1 (cont'd)

Date of Hurricane	(1) Category	Source of Data	Remarks
1933, Aug. 23-24	B	(2)(3)(4)	Driving rain and high tides along Conn. coast.
1933, Sept. 16-17	C	(2)(3)	Passed south of Cape Cod, moving northeast. No reports of damage in Conn.
1934, June 19	C	(2)	Traveled overland from Louisiana; crossed Long Island and Cape Cod, moving northeast.
1934, Sept. 9	B	(2)(4)	Crossed Long Island and Central Conn. moving north. Wind damage along Conn. coast.
1936, Sept. 19	B	(2)(3)(4)	Passed south of Nantucket, heading northeast. Wind damage along Conn. coast.
1938, Sept. 21	A	(2)(3)(4)	Most damaging storm to strike southern New England. 6.7 foot surge at Stratford caused tidal flooding to 9.2 feet msl.
1940, Sept. 2	C	(2)(4)	Passed south of Nantucket, heading northeast. No accounts of damage in Conn.
1940, Sept. 16	C	(2)(4)	Followed northeasterly path east of Cape Cod. No accounts of damage.
1943, Oct. 17	C	(2)(4)	Passed east of Cape Cod, moving due north. No accounts of damage.
1944, Aug. 3	C	(2)(4)	Moved northeasterly along path south of Long Island and Nantucket. No accounts of damage.

TABLE A-1 (cont'd)

Date of Hurricane	(1) Category	Source of Data	Remarks
1944, Sept. 14-15	A	(2)(3)(4)	Center passed over Providence, R.I. and south of Boston, Mass. Surge of 6.4 feet at Stratford caused tidal flooding to 8.8 feet ms.
1944, Oct. 21	C	(2)(4)	Path crossed over Nantucket and tip of Cape Cod. No accounts of damage.
1945, June 26	C	(2)(3)(4)	Followed northeasterly path from Florida to Nova Scotia, passing south of Nantucket.
1945, Sept. 19	C	(2)(4)	Overland from Florida; passed just west of New York, moving northeast.
1949, Aug. 29	C	(2)(3)(4)	Traveled overland from northern Florida, crossed center of Maine High winds at Greenwich Conn.
1950, Aug. 20	C	(2)(3)(4)	Passed south of Nantuck heading generally north east. Heavy rain at Greenwich, Conn.
1950, Sept. 11	C	(2)(3)(4)	Passed south and east o Nantucket, then headed east. No reports of damage in Conn.
1952, Sept. 1 ("Able")	C	(2)(3)(4)	Followed northeasterly track, approximately over New York. Heavy rain and high wind at Greenwich, Conn.
1953, Aug. 15 ("Barbara")	C	(2)(3)(4)	Followed path south of Long Island and Nantuc
1953, Sept. 7 ("Carol")	C	(2)(3)(4)	Passed east of Cape Cod heading generally north

TABLE A-1 (Cont'd)

Date of Hurricane	Category (1)	Source of Data	Remarks
1954, Aug. 31 ("Carol")	A	(2)(3) (4)	Second most damaging storm to hit Conn. coast. Crossed east end of Long Island, moving north. Surge of 5.1 ft. caused flooding to 9.2 ft. msl at Stratford.
1954, Sept. 11 ("Edna")	B	(2)(3) (4)	Passed over Cape Cod heading northeast. High seas, minor damage from wind.
1954, Oct. 15 ("Hazel")	B	(2)(3) (4)	Heavy rainfall and river flooding in the interior of Conn. Mass., and R.I. negligible tidal flooding along coast. Center moved through western New York.
1955, Aug. 12-13 ("Connie")	C	(3)(4)	Caused scare in New England and heavy rainfall but no damage. Storm passed southwest of Washington, D.C.
1955, Aug. 18-19 ("Diane")	B	(2)(3) (4)	Passed just south of Long Island and about over Nantucket. Brought record rainfall to many areas of Conn.; heavy flood damages in river valleys; no tidal-flood damage along coast.
1955, Sept. 20 ("Ione")	C	(3)(4)	Caused scare in New England but no reported damage. Storm turned east and then northeast after passing inland of Cape Hatteras.
1958, Aug. 29 ("Daisy")	C	(3)(4)	Caused scare in New England but no damage. South of Nantucket Island the storm turned east and then northeasterly.

TABLE A-1 (cont'd)

Date of Hurricane	Category (1)	Source of Data	Remarks
1960, July 30 ("Brenda")	B	(3)(4)	Storm crossed coast just west of Bridgeport and continued into western Conn. and Mass. Some minor wind damage; negligible tidal flooding.
1960, Sept. 12 ("Donna")	B	(3)(4)	Storm crossed coast near New London continued over Worcester, Mass. and into N.H. Tides 4 to 5 feet above normal along southern coast of New England caused flood damage at a number of localities.
1961, Sept. 21 ("Esther")	B	(3)(4)	Northerly movement of storm stopped south of Nantucket, weakened, made clockwise loop and passed off to the east without crossing the New England coast line. Surge caused tidal flooding to 7.3 ft. msl at Stratford.

Notes:

(1) The following assigned categories pertain to the effect of a hurricane on the coast of Connecticut.

A: Caused severe tidal flooding.
B: Caused damage from wind or rainfall (usually accompanied by high seas and moderate tidal flooding).
C. Threatened area.

(2) "Hurricanes -Their Nature and History", By I.R. Tannehill (1956)

(3) Local newspaper accounts, histories, etc.

(4) Material furnished by U.S. Weather Bureau.

A-3. DESCRIPTIONS

Brief descriptions of type " A" and type "B" hurricanes experienced along the Connecticut coast from 1770 to 1930, as recorded by historians and as reported in newspaper accounts and other records are given below. Also, included are descriptions of four severe hurricanes (Category "A") that are reported to have struck Rhode Island and Massachusetts prior to 1770 but for which no accounts have been found regarding their effect on Connecticut coastal areas. Subsequent to 1930, numerous and more adequate records are available of storm occurrences, including data on tidal-flood levels, wind velocities, and other storm characteristics.

a. 15 August 1635. From "Of Plymouth Plantation, 1620-1647," by William Bradford.

"This year the 14 or 15 of August (being Saturday) was such a mighty storm of wind and rain, as none living in these parts either English or Indian, ever saw, being like (for the time it continued) to those Hauricanes and Tuffons that writers make mention of in the Indies. It began in the morning, a little before day, and grew not by degrees, but came with violence in the beginning to the great amazement of many. It blew down sundry 211 houses, and uncovered others; divers vessels were lost at sea, and more in danger. It caused the sea to swell (to southward of this place) above 20 feet, right up and down, and made many of the Indians to climb into trees for their safety; it took off the board roof of a house which belonged to this plantation at Manamet, and floated it to another place, the posts still standing in the ground; and if it had continued long without the shifting of the wind, it is like it would have drowned some part of the country. It blew down many hundred thousands of trees, turning up the stronger by the roots, and breaking the higher pine trees off in the middle, and the tall young oaks and walnut trees of good bigness were wound like a withe, very strange and feaful to behold. It began in the southeast and parted toward the south and east, and veered sundry ways; but the greatest force of it here was from the former quarters. It continued not (in the extreme) above 5 or 6 hours but the violence began to abate. The signs and marks of it will remain this 100 years in these parts where it was sorest. The moon suffered a great eclipse in the second night after it."

From: "The History of New England from 1630 to 1649," by John Winthrop.

"...This tempest was not so far as Cape Sable, but to the south more violent, and made a double tide all that coast...

"The tide rose at Narragansett fourteen feet higher than ordinary and drowned 8 Indians flying from their wigwams."

b. 3 August 1638. From: "The History of New England from 1630 to 1649," by John Winthrop.

"In the night was a very great tempest of hiracana at S.W. which drave a ship on ground at Charlestown, and brake down the windmill there, and did much other damage. It flowed twice in 6 hours and about Narragansett it raised the tide 14 to 15 feet above the ordinary spring tides upright."

c. 30 October 1723. From: "The Boston News-Letter, No. 1032... From Thursday, October 31, to Thursday November 7, 1723."

"Rhode Island, November 1 .....

"...On Wednesday last we had here a very great South East storm of Wind & Rain, and a very high Tide, a Foot higher than ever was known before, which has broken & carried away several of our Wharfs, and drove some vessels ashore from their anchors and has done considerable damage in Warehouses and Cellars, to dry goods, and other merchandize; the Loss is computed to some thousand pounds...."

d. 24 October 1761. From: "The Boston News-Letter, No. 2991. Thursday, October 29, 1761."

"Last Friday evening between 8 and 9 o'clock came on the severest N.E. Storm of Wind and Rain that has been known here for 30 Years past, and continued 'till between 2 and 3 o'clock next morning;... Five or six Vessels were drove ashore at Providence in Rhode Island Government, and greatly damag'd and it being high Water there it got into the Stores and Cellars and damag'd Sugars &c to the amount of 12 or 15,000 (pounds) their Currency; it has also entirely carried away the great Bridge at that Place. - On both roads East and West, so far as we have heard, the Roofs of Houses, Tops of Barns, and Fences, have been blown down, and it is said Thousands of trees have been torn up by the Roots by the violence of the above storm, and we fear we shall hear melancholy Accounts of Damage done at Sea."

From: "The Newport Mercury," October 27, 1761.

"On Friday last came a terrible storm from the North-east, which continued increasing with a very heavy rain, and did not abate till after 2 in the morning. The violence of the wind broke off part of the steeple of Trinity Church. Several persons sustained considerable loss in their sugar, salt, etc. by the prodigious rise of tide, which flowed into their stores and cellars. Many of the ships in the harbor were driven ashore from the wharves and their moorings, but without any considerable damage except to two ships. Sad havoc has been made with the lumber and wood on the wharves,

great quantities of fence blown and numbers of trees torn up by the roots. People hardly thought themselves safe in their own houses, for a more violent storm has scarce ever been known here."

e. 19-20 October 1770. (Type "A"). "History of the State of Rhode Island," by Samuel Greene Arnold.

"A violent storm again blew down a part of the spire of Trinity Church at Newport and caused an immense loss of life and property along the coast. Newport suffered very severely in this gale."

From: "The Connecticut Journal," November 21, 1770.

"New London, Oct 26.

"On Friday Night and part of the next Day we had a very Severe Storm of Wind and Rain From the N.E. by which two Vessels were drove ashore in this Harbor but received little or no damage."

f. 19 September 1787. (Type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"Line storm. A mill at Stamford carried off whole and Norwalk bridge floted."

g. 19 August 1788. (Type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"The hardest gale that has been for many years--- at 1 o'clock a Sloop & Schooner went on shore---. The Gale reached 100 miles up country, in some places shifting from SE to NW & twisting of trees 9 inches in diameter--- it moved Carson's house about 6 feet."

From: "The New Haven Gazette and the Connecticut Magazine," Thursday, August 21, 1788.

"New Haven.

"Last Tuesday morning came on a violent gale of wind from the South which at about one o'clock P.M. veered to S.S.W. and blew a perfect hurricane.

"Several vessels were driven ashore and very material damage is done to the long Wharf... We expect to hear of much damage done at sea and in the harbours on our coast...."

From: "The Connecticut Courant and Weekly Intelligence," Monday, August 25, 1788.

"New Haven, Aug. 20.

"Yesterday we had a violent gale of wind, the height of which was from the S.E. about one o'clock. Though the tide was not full as has been frequent in easterly storms, considerable damage was done to the Long-Wharf by the violence of the waves and several vessels parted their masts, but the shipping received no material damage. The Indian corn is much injured and the trees stripped of their fruit and some apple trees blown down."

h. 9-10 October 1804. (Type "B"). From: The Connecticut Courant," October 17.

"The partial and summary accounts which have been received from the neighboring towns, though they afford no particulars of the effects of the late gale, sufficiently evince the widespread destruction which has been experienced by it. In almost every direction the fruit and other trees have been generally blown down, the fences destroyed and much damage done by the heavy rain, which fell during the storm."

i. 22-23 September 1815. (Type "A"). From: "Connecticut Herald," New Haven, September 26.

"The storm--On Friday night and Saturday morning last a severe storm of wind and rain was experienced in this vicinity...The most material injury sustained here was to Long Wharf, which was entirely inundated by the highest tide known for a great number of years. Everything movable on the wharf was swept away. The water in some of the stores was nearly two feet deep, but no great loss of property took place except in a quantity of rum which was swept from the wharf, several hogshead of which have not yet been recovered."

From: "The Connecticut Courant," October 4.

"Bridgeport, Sept. 27.

"The late Storm which commenced on Thursday last continued with increasing violence until 11 o'clock on Saturday morning. The wind during the whole time blew a severe gale accompanied with rain from the N.E. and had so much increased the waters in the Sound that the tide, which in ordinary weather would have been full at 2 o'clock and 44 minutes, attained its greatest height at 12 o'clock 30 minutes, and was then near six feet above common flood tides; and had it not fortunately happened that the wind some hours before the tide was at full veered round to the N.W. it must have risen to an alarming height. The oldest inhabitants do not remember so high a tide by nearly one foot. The water through the whole length of Water Street was of sufficient depth for the largest long boat to pass loaded with passengers. Considerable damage has been sustained in the stores along the shore by the destruction of salt, grain and other bulky articles that could not speedily be removed.

From: "Connecticut Herald," New Haven, October 5, 1815.

"The late storm has done incalculable damage to roads and bridges, especially on the sea coast, where the tides assisted its destructive power. No mail from Boston has arrived since Saturday last, undoubtedly owing to the road being damaged, and the bridges carried away. An old citizen of New Haven who has been particularly attentive to the subject has informed us that forty-five years ago there was a remarkable high tide in this town which did not, however, rise as high by four inches, as the one on Saturday last.--Had not the wind, two hours and a half before high water, suddenly shifted to the westward, it is impossible to tell what damage might have been sustained by inhabitants on the Sound."

j. 3 September 1821. (Type "A"). From: "Connecticut Herald," New Haven, Tuesday, September 11.

"We were visited in the evening of the 3d inst. by a toronado almost unexampled in this latitude. The gale commenced at S.E. about 6 o'clock but was most violent from 8-10, the wind then varying from S.S.E. to S.W.--nearly all vessels in the harbor were driven by the force of the storm, and are more or less damaged... Fortunately

at the height of the gale it was time of low water; otherwise, damage to shipping, wharves, stores &c, must have been incalculable...The rafters and gable end of a brock store on the wharf...were blown down...part of a roof of Mr. Thomas Hunt's dwelling in Water St. was torn off...scarcely a street was exempted from falled chimnies and fences. Several trees were upturned by the roots...the leaves of most of which remain are changed to a singular dark brown hue.

"Part of the first bridge on the pier was carried away by the driving of a sloop, who struct upon her stem.

"At Bridgeport, several buildings were blown down or unroofed...Almost all the vessels in port were driven ashore, but without much injury.

* * *

"New London, September 5.

"Severe Gale.---On Monday night last we experienced a severe gale from the South-East. It commenced at 7 in the evening and lasted until midnight. The tide rose several feet above its ordinary level and some damage was done to our wharves and boats..."

From: "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"A tremendous gale of wind E and SE from 6 to 11 in the evening passed over this place--tore down many--trees... every vessel went ashore in this harbor---A sloop dismasted in the sound and the lighthouse laid flat. The hardest gale ever remembered.

"The leaves of the trees as in 1788 are turned brown... small limbs of trees blew thirty rods---there was a continual roaring like thunder..."

k. 2-4 October 1841. (Type "B"). From: "Hartford Daily Courant," Tuesday, October 5.

"Severe Storm--We have been visited by a most remarkable storm--the like of which, so early in the season, on account of its severity and continuance, is not remembered by our oldest inhabitants. On Saturday night it commenced raining, the wind from the northeast, and continued without intermission, intermingled a part of the time with snow and accompanied by

wind until sometimes yesterday afternoon. During a part of Sunday night, the wind blew a perfect hurricane, and the rain came down in torrents...Many valuable fruit and ornamental trees have been prostrated or stripped of their limbs...as the storm undoubtedly extended along the coast, we may expect to hear of damage from that quarter.

l. 29 -30 October 1866. (Type "B"). From:"Hartford Daily Courant," October 31.

"One of the hardest storms of the season prevailed on Monday and continued through yesterday. It was a regular southeaster---one of those violent storms that often haunt us at this season of the year....The wind prostrated the lines between New Haven and New York and at other places east and south. The steamer Granite State left New York at the usual hour on Monday and met with rough weather on the Sound...."

m. 8 September 1869. (Type "A"). From: "Norwich Morning Bulletin," September 12, 1869.

"Storm(at Mystic, Conn.) worse since 1815. Came at low water and the tide, though rising higher than it has for 2 or 3 years, did less damage than it otherwise would have done. Had it occurred at highwater, the bridge and a large part of Mystic would have submerged. The tide rose at the rate of an inch a minute, walling up a foot high where it struck the spiles at the bridge."

n. 22-23 October 1878. (Type "A"). From: The Daily Standard, Bridgeport, October 23, 1878.

"A section of the fence...opposite the depot blew down this morning.

"A portion of the bulletin board corner High and Main Streets blew down this morning. Limbs were broken off the trees in all sections of the city.

"The storm last night and this morning drove a number of small boats ashore below the Naugatuck dock and their owners turned out and dragged them beyond reach of the waves....

"The sea held high carnival at Sea Side Park this morning, and a wilderness of rolling white caps and tempest of dashing spray bore witness to the disturbed mood of the waters, angered by the howling winds..."

From: "Greenwich Observer," October 24, 1878

"...The storm yesterday was very severe and the shipping in our harbor was roughly tossed. The tide rose to a remarkable degree..."

From: "The Daily Standard," Bridgeport, October 24, 1878

"New Haven, Oct. 23d,---The steamer John Bramhall, Captain Pollard, from this city, ashore on Little Cull Island, has gone to pieces in the gale."

o. 10 December 1878. (Type "B"). From: "The Providence Daily Journal," Providence, Rhode Island, Wednesday, December 11, 1878.

"Yesterday was a rainy day***and the wind blew mightily from the southeast in fitfull gusts*** Toward evening the wind increased in fury and power*** The wind did not decrease in volume or strength until 8:00 and the rain fell as rapidly as during the day.

"**. A floating bath house above India Bridge (Providence) was blown from its mooring. A ship broke loose. Cellars flooded, some up to 8 inches.

"The water in the river (Providence River) rose very high, higher than before this year*****. Fortunately the wind went down about an hour before high water and danger was averted. This is the second time this year in which the gale ceased an hour or so before high tide. Water washed over the Dorrance Street wharf. Dyer Street cellars got a little water."

"Hartford, Conn., December 10 - The storm and gale was very severe here this afternoon and at its height about 6:00 o'clock. Several chimneys were blown down and buildings unroofed."

p. 18 August 1879. (Type "B"). From: "Stamford Herald," (Weekly) August 20.

"---From a test made at Waterside the rainfall during the last storm was found to be 8 inches. On Monday from 7 a.m. till 7 p.m. a little over 4½ inches fell.

"A more soaking continuous and persistent rainstorm we have seldom experienced in August...Corn has suffered under the infliction of so much rain and wind..."

q. 10 September 1889. (Type "B"). From: "The Greenwich News," Friday, September 13.

"The furious northeaster which has been raging along the Atlantic coast for the past few days is one of the severest storms known in this vicinity for years, and one of the most destructive to property. Ever since Tuesday when the storm reached here from the Atlantic, it has blown a gale, mostly from the northeast, accompanied nearly all of the time by rain.

"The greatest force of the storm has been felt along the coastline...small craft along the shore have suffered severely...

"Greenwich has suffered comparatively little from the storm. A few trees have been blown down and the roads have been damaged more or less, but beyond this there was scarcely any damage done. On Tuesday there was a very high tide in the harbor and at one time part of the steamboat dock was under water...the only loss reported along the shore are one or two row boats."

* * *

"The schooner Annie Jacobs from New Haven...was beached on Mansuring Island during the storm Tuesday night."

From: "The Greenwich Opinion, September 20.

"The crib dock which Mr. J.D. Barrett has erected on his property at Belle Haven was washed away by last week's storm.

r. 23-24 August 1893. (Type "A") From: "Stamford Advocate," August 24.

"One of the most severe storms of wind and rain ever experienced in this locality started last night and continued increasing in force until this forenoon. The evidences of its severity were to be seen on every hand...streets washed out and flooded, building damaged...

"Every boat in the harbor was adrift...The tide rose higher than has been known for some time. All the

streets in the vicinity of Waterside were impassable, the water coming up over the meadows to the foot of Atlantic Street...

"The scene in the lower harbor at high tide this morning was a wild one...On the whole the craft in the lower harbor escaped well, much better probably than they would have done had a gale of equal force come in from the southwest."

s. 29 August 1893. (Type "B") From: "The Day," New London, Connecticut, Tuesday, August 29, 1893.

"The storm today has been free from some of the disagreeable accompaniments that made last Thursday's blow one of the worst experienced in this vicinity in recent years.***

"The tide was very high all the morning, nearly up to the string pieces on the bulkheads and almost washing the timbers of the deck of the railroad bridge at the upper end of town.

"Down at Ocean Beach the scene today was grandeur, if possible, than last week. The surf was heavier and there was much more of it. It rolled in way up to the embankment, great breakers at least 10 feet high washing over the wharf***. Alewife Cove was filled again way to the new road, and things in that locality had about the same appearance as last week."

t. 9-10 September 1896. (Type "B") From: "The Providence Daily Journal," Providence, Rhode Island, Thursday, September 10, 1896.

"The storm which began yesterday morning, came unheralded, as all northeast storms do******.

"The storm was a most peculiar one, for while the wind was offshore the sea was constantly increasing, and at nightfall it dashed in upon the rocky shore and the spray being thrown fully 25 feet in the air.

"At Block Island the storm was considered the severest on record at this season of the year. Late in the afternoon the wind velocity was recorded at 76 mph with no signs of abating."

u. 16 September 1903. (Type "B"). From: "The Bridgeport Daily Standard," September 17.

"Very strong winds and rain unroofed houses, felled or uprooted trees.

"...a casual survey of the damage along the water-front shows it will run into the thousands...

"At the Bridgeport Yacht Club in the Black Rock Harbor there was damage galore, and but for the active work of the yachtsmen there would have been several fine yachts totally wrecked.

"Although the waves were very high the water did comparatively little damage...no water ever reached the roadway although everybody was completely drenched with the spray which rose in a long continuous, heavy white cloud the whole length of the sea wall."

*****

"New Haven, September 17. Wind, rain and a phenomenally high tide combined to make the damage in and about New Haven very expensive.

"The bathing pavilion in the rear of Mrs. Albert Wintter's residence at 313 Seaview Avenue was blown in the water."

From: "The Daily Advocate," Stamford, September 16.

"The storm which is raging all over this section struck Stamford with a vengeance at noon today and inside of an hour it had shaped itself into what old-timers say, is the swiftest easterly storm experienced for twenty years or more.....

"On the east shore of Shippan, the storm was felt with great severity, and the same is true of Sound Beach where there are a number of summer cottages near the shore.

"The wind blew great guns...rain fell in veritable sheets. On exposed corners this was particularly noticeable, the pavements being under a constant wash of water... The wind came from the east and blew at from 75 to 80 miles an hour."

v. 15 September 1904. (Type "B"). From: "New Haven Evening Register," September 15.

> "At one time early this morning, shortly after midnight the wind being then at the southwest, blew at the rate of 40 miles an hour...During the entire progress of the storm in New Haven 3.96 inches of rain fell...At Casey Beach, during the early part of the storm, the shore was heavily lashed by angry waves and for a time it seemed as though some of the lighter of the houses would be thrown from their foundations. Then the wind shifted and blew offshore and the water smoothened...Trees were uprooted and oyster beds damaged by the winds...."

w. 13 November 1904. (Type "B"). From: "New Haven Evening Register," November 14.

> "Here in New Haven the wind in yesterday's gale blew as high as 50 miles an hour. Many telephone and telegram wires were prostrated and there was some light wreckage about the harbor..."

x. 30 Sept. - 1 Oct. 1920. (Type "B"). From: The Daily advocate," Stamford, October 1.

> "The wind attained a velocity of 60 miles an hour, and it roared along the shorefront in an alarming manner, but did no great actual damage there. It veered from south by east, late in the afternoon to a more southerly direction as to the night wore on. Its greatest velocity was attained about midnight. That was sufficient to rock some houses on their foundations.
>
> "Boats were torn from their moorings and trees were blown down."

****

> "Norwalk, Oct. 1--Last night's storm here was the worst in years, doing damage along the Sound shore. The tide reached a record height at 1 a.m., the water covering the roads and wrecking a number of cottages at Belle Island...12 small boats were carried ashore and wrecked... and much damage done by the wind."
>
> "New Haven, Oct. 1. Thousands of dollars of damage was done along the Sound shore last night by one of the worst storms in several years. Driven by a gale which exceeded 40 miles from the southwest and accompanied by

a high tide. The waves rolled mountain high against the beach during the night, the tide reaching a record height about midnight. Many boats were washed ashore, cottages, piers and breakwaters being partially wrecked.

"At the Weather Bureau this morning it was stated that the wind reached a velocity of 42 miles at the height of the storm. A total rainfall yesterday and last night of 2.51 inches was recorded."

y. 26 August 1924. (Type "B"). From: "Standard Sentinel," August 27.

"Nothing like the devastation of felled wires, cables and poles in the eastern part of the State ever has been experienced by the telephone people..."

****

"New Haven, Conn. Aug. 27.--With approximately 6,000 telephones out of commission in the territory east of Saybrook, a section of the State severely hit by a juvenile tornado late yesterday afternoon the Southern New England Telephone Company suffered more damage than...in a great many years..."

z. 2 October 1929. (Type "A"). From: "New Haven Journal-Courier," October 3.

"Damage which will probably total thousands of dollars was done yesterday along west shore in Milford by the lashing northeaster which swept northward from the Caribbean.. its ferocity had been largely spent by the time it had reached the shores of Long Island Sound...

"The largest damage reported from along the shore yesterday came from Silver Beach in Milford where the strong northeasterly and easterly gale created waves at the high tide hour this morning which tossed one cottage off its foundations....

"High tides came near flooding street car tracks where they pass close to the water's edge on the shore runs, it was said, but no delays were brought about by this cause.

The protection would continue along the bank of the river for a distance of about 2,500 feet, in a westerly direction. This portion of the protection would consist of improving the existing gravel and clay dike at the Avco Plant by raising its height approximately 4.0 feet, to an elevation of 16.5 feet msl, through the placement of additional fill. The modified dike would have stone on its top and seaward slope and seeded topsoil on its landward slope. It would retain its present top width of 12 feet and side slopes of 1 on 2.5 on the seaward side and 1 on 1.5 on the landward side. A 15-foot wide berm, at elevation 9.0 feet msl, would be included on the seaward side. The top of the dike would be paved as it would continue to be utilized as a patrol road.

From the west end of the Avco dike the protection continues north along the bank of the river, passing in front of the sewage treatment plant, to the south side of Birdseye Street, a distance of about 2,530 feet. It then runs about 200 feet to the west, crosses Birdseye Street, and ties into high ground about 740 feet to the north, at the south side of the knoll located between Birdseye Street and South Avenue. This latter protection, with the exception of 200 feet of concrete wall along the south side of Birdseye Street and approximately 960 feet of low diking with seeded topsoil on its top and both faces, would consist of diking with rock on its top and seaward slope and seeded topsoil on its landward slope. The diking would have a top width of 10 feet, for most of its length, at elevations ranging from 14.0 to 16.0 feet msl. For about 350 feet of its length, in front of the sewage treatment plant, the dike follows Beach Street, the road which affords access to the property south of the treatment plant. This portion of the dike would have a top width of 25 feet to accommodate Beach Street which would be elevated to the top of the dike.

To complete the protection along the Housatonic River requires (1) approximately 320 feet of dike, with rock on the top and riverside slope and seeded topsoil on the landward slope, across the tidal inlet on the south side of South Avenue, and (2) about 1,150 feet of rock-faced dike, with seeded topsoil on its landside slope, running north from high ground on the north side of Stratford Avenue, along the banks of the Housatonic River and Ferry Creek, to Broad Street. These latter two lengths of dike, totalling approximately 1,470 feet, would have a top width of 10 feet at an elevation of 15.5 feet msl. Closure from the upper end of the diking to high ground at Broad Street and Housatonic Avenue would be accomplished by 260 feet of low concrete wall along the south side of Broad Street.

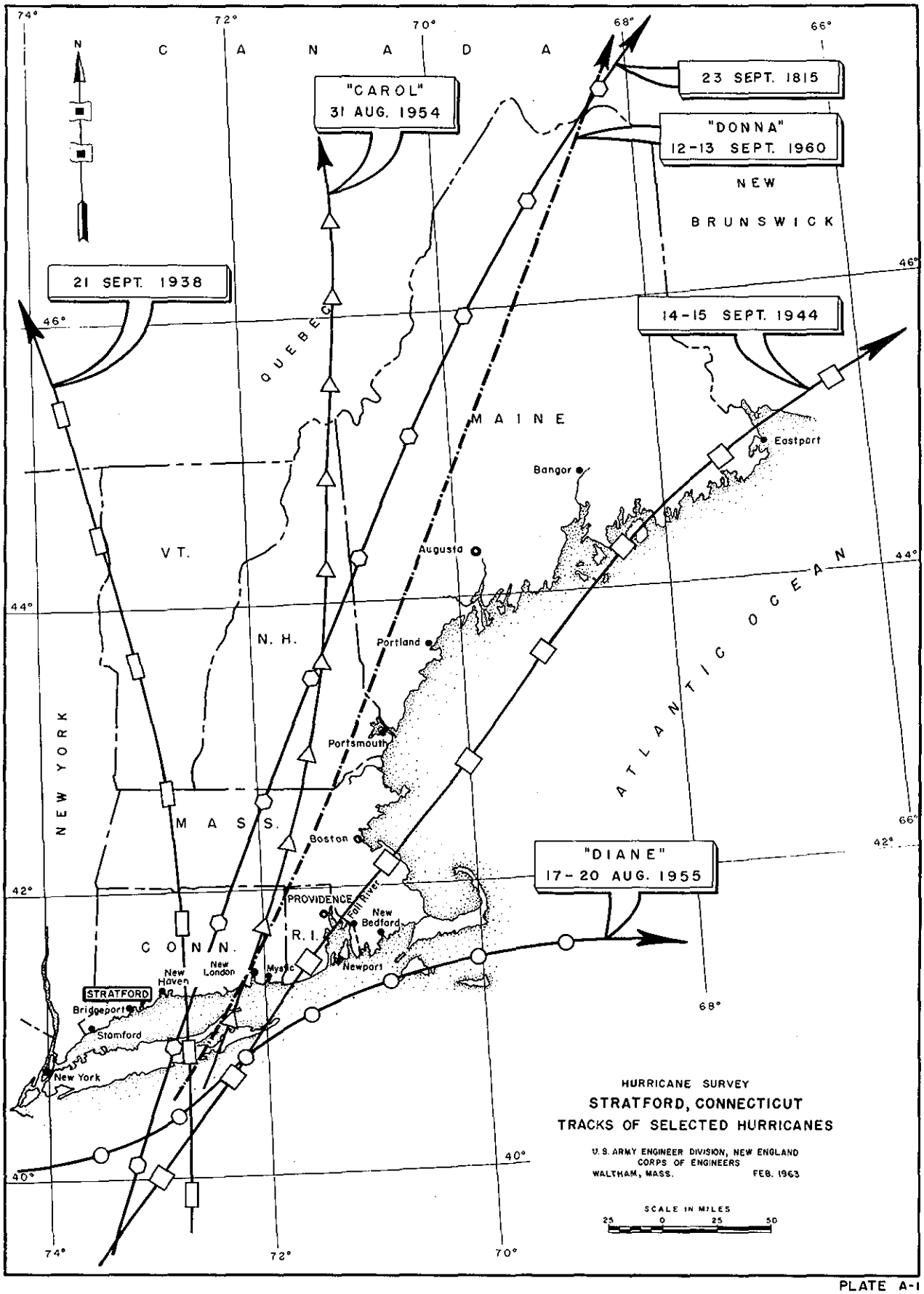

"CAROL"
31 AUG. 1954
23 SEPT. 1815
"DONNA"
12-13 SEPT. 1960
21 SEPT. 1938
14-15 SEPT. 1944
"DIANE"
17-20 AUG. 1955
CANADA
NEW BRUNSWICK
QUEBEC
MAINE
VT.
N. H.
MASS.
CONN.
R.I.
NEW YORK
ATLANTIC OCEAN
Eastport
Bangor
Augusta
Portland
Portsmouth
Boston
PROVIDENCE
Fall River
New Bedford
Newport
Mystic
New London
New Haven
STRATFORD
Bridgeport
Stamford
New York
74°
72°
70°
68°
66°
46°
44°
42°
40°
HURRICANE SURVEY
STRATFORD, CONNECTICUT
TRACKS OF SELECTED HURRICANES
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1963
SCALE IN MILES
25 0 25 50

PLATE A-1

APPENDIX B

HYDROLOGY AND HYDRAULICS

APPENDIX B

HYDROLOGY AND HYDRAULICS

TABLE OF CONTENTS

Paragraph	Title	Page
B-1	INTRODUCTION	B-1
	HYDROLOGY	
B-2	Temperature and Precipitation	B-1
B-3	Drainage Areas	B-1
B-4	Storm Rainfall	B-3
B-5	Hurricane Winds	B-3
B-6	Hurricane Barometric Pressures	B-4
B-7	Runoff	B-7
	HYDRAULICS	
B-8	Hurricane or Storm-Tide Flood Levels	B-7
B-9	Standard Project Storm-Tide Derivation	B-10
B-10	Design Tidal-Flood Level	B-10
B-11	Design Waves	B-10
B-12	Wave Runup and Overtopping	B-12
B-13	Ponding and Pumping	B-12

TABLES

Number	Title	Page
B-1	Monthly Temperatures and Extremes	B-2
B-2	Monthly Precipitation	B-2
B-3	Wind Velocities	B-5
B-4	Minimum Barometric Pressures	B-6
B-5	Interior Runoff - 10 year, 6-Hour Rainfall	B-8
B-6	Tidal Elevations vs Frequency Data	B-9
B-7	Wave Runup and Overtopping	B-13
B-8	Ponding of Runup and Overtopping	B-15

APPENDIX B - TABLE OF CONTENTS

PLATES

Number	Title
B-1	Location Map for Hurricane Flood Level Profile, Fairfield to Branford, Conn.
B-2	Hurricane Flood-Levels Profile, Fairfield to Branford, Conn.
B-3	Tide Curves, Design, 1938, 1944 & 1954 Hurricanes
B-4	Frequency of Tidal-Flooding from Hurricanes and Storms
B-5	Drainage Areas Contributing Runoff to Protected Area
B-6	Area and Capacity Curves, Great Meadows-Frash Pond and Ferry Creek above Broad Street
B-7	Area and Capacity Curves, Selby Pond and Marine Basin
B-8	Area and Capacity Curves, South Avenue and Sewage Treatment Plant

APPENDIX B

HYDROLOGY AND HYDRAULICS

INTRODUCTION

B-1. This appendix presents data to supplement the sections of the main report relating to hydrology and hydraulics. It includes a summary of temperature and precipitation data to amplify the section of the report on "Climatology," and data on hurricane wind velocities, rainfall values, and barometric pressures to augment report material on the characteristics of hurricanes. A determination of tidal-flood levels and design storm tide, and detailed analyses of wave height, runup, overtopping and ponding are also included.

HYDROLOGY

B-2. TEMPERATURE AND PRECIPITATION

Records of temperature and precipitation, covering a period of nearly 70 years, are available for the U.S. Weather Bureau Station at Bridgeport, Connecticut, which adjoins Stratford to the west. These records are considered to be representative of conditions at Stratford. Monthly means and extremes of temperature for 66 years of record at Bridgeport, and mean, maximum, and minimum monthly precipitation data for 68 years of record, are summarized in Tables B-1 and B-2.

B-3. DRAINAGE AREAS

The total drainage area behind the recommended protection at Stratford comprises approximately 3,830 acres. This includes an area of 2,180 acres, south of the Connecticut Turnpike and tributary to Lewis Gut, which, for the most part is relatively flat, at and below an elevation of 10 feet msl, with a few locations near the turnpike at elevations of approximately 25 feet msl. Above Broad Street at Ferry Creek there is a drainage area of 1,330 acres of which approximately one-fourth, located south of the railroad, is at elevations below 25 feet msl. Above the railroad the area extends north about two miles to an elevation of about 150 feet msl. Much of the western perimeter and about one-half of the eastern perimeter of the area, north of the railroad, is at elevations in excess of 100 feet msl. The remaining 320 acres of drainage area

TABLE B-1

MONTHLY TEMPERATURES AND EXTREMES (1896-1961)

Bridgeport, Connecticut

	Degrees Fahrenheit				Degrees Fahrenheit		
Month	Mean	Maximum	Minimum	Month	Mean	Maximum	Minimum
Jan.	29.5	68	-14	July	73.1	103(2)	44
Feb.	29.9	70	-20(1)	Aug.	71.3	101	38
Mar.	37.8	85	1	Sep.	65.2	98	32
Apr.	48.1	97	9	Oct.	54.5	90	20
May	57.0	95	26	Nov.	43.5	80	8
June	67.5	99	34	Dec.	32.3	67	-12
				Annual	51.0		

(1) 9 Feb. 1934 (2) 22 July 1957

TABLE B-2

MONTHLY PRECIPITATION (1894-1961)

Bridgeport, Connecticut

	Inches				Inches		
Month	Mean	Maximum	Minimum	Month	Mean	Maximum	Minimum
Jan.	3.76	7.88	0.51	July	4.05	18.77(2)	0.45
Feb.	3.47	6.32	.85	Aug.	4.45	13.29	.20
Mar.	4.18	9.64	.29	Sep.	3.73	14.15	.09
Apr.	3.90	9.41	.69	Oct.	3.64	10.72	.30
May	3.78	10.18	.49	Nov.	3.78	7.60	.81
June	3.29	8.48	.06(1)	Dec.	3.83	9.85	.33
				Annual	45.87	64.23(3)	29.57(4)

(1) June 1949 (2) July 1897 (3) 1957 (4) 1901

is located along the west bank of the Housatonic River, at and below the mouth of Ferry Creek. Most of this area is at elevations below 10 feet msl with a few locations along the upper end of the western perimeter, west of Main Street, rising about five feet higher to an elevation of about 15 feet msl.

B-4. STORM RAINFALL

The total rainfalls associated with recent hurricanes that have caused tidal flooding in Stratford, based on records for Bridgeport, are: 11.16 inches in September 1938, 10.74 inches in September 1944, and 1.72 inches in August 1954 (Hurricane "Carol"). The maximum 6-hour rainfalls for these three storms at Stratford are: 1.80 inches in 1938, an estimated 3.50 inches in 1944, and 1.13 inches in 1954. The maximum 6-hour rainfall for the 1944 hurricane approximates a rainfall of 10-year frequency; the maximums in the 1938 and 1954 hurricanes, less than a one-year frequency. (See Weather Bureau Technical Paper No. 29, "Rainfall Intensity-Frequency Regime," Part 4 - Northeastern United States). Owing to the time required, about 2.0 hours, for a hurricane surge to travel up Long Island Sound to Stratford, from the eastern entrance to the Sound, the peak rainfalls at Stratford in the recent hurricanes of record have been experienced prior to the occurrence of the peak stages of tidal flooding.

The storm of 14-17 October 1955, not a hurricane, caused five successive high tides at Stratford which reached elevations of nearly 8.0 feet msl, approximately 4.4 feet above mean high water. The rainfall in this storm at Stratford totalled 7.15 inches; 2.85 inches in 6 hours. This rainfall has a frequency of less than 10 years.

B-5. HURRICANE WINDS

The most reliable data on experienced hurricane wind velocities in New England begin with the September 1938 hurricane. The maximum velocity in New England during this storm was a recorded gust of 186 mph at the Blue Hills Observatory in Milton, Massachusetts, where a sustained 5-minute wind of 121 mph was also recorded. At other locations in southern New England, sustained 5-minute velocities ranging from 38 to 87 mph were experienced.

During the hurricane of 14 September 1944, a maximum gust of 109 mph was registered at Hartford, Connecticut. Sustained 5-minute velocities ranging from 33 to an estimated 85 mph were recorded at a number of locations between New York City and Block Island, Rhode Island, during this same hurricane.

In southern New England, during Hurricane Carol (31 August 1954) gusts of 125 and 135 mph were experienced at Blue Hill, Massachusetts, and Block Island, Rhode Island, respectively. Sustained 1-minute velocities ranging from 38 to 98 mph were registered.

Recorded wind velocities at a number of locations in southern New England and New York City, for the three great hurricanes of 1938, 1944, and 1954, are given in Table B-3.

The wind data in Table B-3 are for historical hurricanes that passed to the east of Stratford and caused high surges to enter the east entrance of Long Island Sound. The winds at Stratford in these three hurricanes were, in general, from the northern sector. This tended to decrease wave action in the Stratford area. Hurricanes passing to the west of Stratford by a distance of 50 miles or so would produce critical winds from the southern sector. These winds would cause greater wave action.

B-6. HURRICANE BAROMETRIC PRESSURES

The center or "eye" of the 1938 hurricane entered Connecticut about 25 miles east of Stratford at about 3:30 PM, EST, on 21 September and then proceeded northwesterly at a rate of 50 to 60 mph. The lowest pressure registered during the passage of this storm was 28.04 inches at Hartford, Connecticut.

In the hurricane of 14 September 1944, the "eye" of the storm passed inland between Charlestown and Point Judith on the south coast of Rhode Island (80 miles east of Stratford) at about 10:20 PM., EST. It then continued in a northeasterly direction veering out to sea at Boston, Massachusetts. The minimum recorded barometric pressure in southern New England during this storm was 28.31 inches at Point Judith.

The center of Hurricane "Carol" (31 August 1954) crossed the south shore of Connecticut in the vicinity of New London (55 miles east of Stratford) at about 10:30 AM, EST, and then followed a general northerly path across New England. The minimum barometric pressures in New England upon the occasion of this hurricane were 28.20 inches at Storrs, Connecticut, (65 miles northeast of Stratford) and 28.26 inches at New London.

The minimum pressures recorded at a number of New England locations and New York City during these three great hurricanes of the past 22 years are given in Table B-4.

TABLE B-3

WIND VELOCITIES

New England Hurricanes of 1938, 1944, and 1954

Velocity in Miles Per Hour

Location	Sustained 5-Min.	Sustained 1-Min.	Maximum Gusts	Direction
Hurricane of 21 September 1938				
New York, N.Y.	70	-	80	NW
New Haven, Conn.	38	-	46	NE
Hartford, Conn.	46	-	59	NE
Block Island, R.I.	82	-	91	SE
Providence, R.I.	87	95	125*	SW
Milton, Mass. (Blue Hill Observatory)	121	-	186	S
Hurricane of 14 September 1944				
New York, N.Y.	81	99	-	N
New Haven, Conn.	33	38	65	N & NE
Hartford, Conn.	50	62	109**	N
Point Judith, R.I.	85*	90*	-	SSE
Block Island, R.I.	82	88	100	SE
Providence, R.I.	43	49	90	SE
Milton, Mass. (Blue Hill Observatory)	67	77	-	-
Hurricane of 31 August 1954				
New York, N.Y.	-	-	61	NW
Bridgeport, Conn.	-	-	60	-
Hartford, Conn.	-	56	64	NE
New Haven, Conn.	-	38	65	N
Block Island, R.I.	-	98	135	SE
Providence, R.I.	-	90	105	ESE
Milton, Mass. (Blue Hill Observatory)	-	93	125	SE

* Estimated
** Taken from indicator; clocked for 4 seconds

TABLE B-4

MINIMUM BAROMETRIC PRESSURES

New England Hurricanes of 1938, 1944, and 1954

Location	Time (EST)	Barometer (inches)
Hurricane of 21 September 1938		
New York, N.Y.	2:45 PM	28.72
New Haven, Conn.	3:30 PM	28.11
Hartford, Conn.	4:17 PM	28.04
Block Island, R.I.	3:05 PM	28.66
Providence, R.I.	3:45 PM	28.90
Milton, Mass. (Blue Hill Observatory)	-	29.01
Hurricane of 14 September 1944		
New York, N.Y.	7:15 PM	29.08
New Haven, Conn.	8:50 PM	28.86
Hartford, Conn.	9:50 PM	28.94
Point Judith, R.I.	10:20 PM	28.31
Block Island, R.I.	10:09 PM	28.34
Providence, R.I.	11:15 PM	28.51
Milton, Mass. (Blue Hill Observatory)	12:11 AM(15 Sep.)	28.62
Hurricane of 31 August 1954		
New York, N.Y.	-	29.6
Bridgeport, Conn.	-	29.9
New Haven, Conn.	9:10 AM	28.77
Storrs, Conn.	11:00 AM	28.20
New London, Conn.	10:00 AM	28.26
Block Island, R.I.	10:00 AM	28.50
Providence, R.I.	11:12 AM	28.79
Milton, Mass. (Blue Hill Observatory)	-	29.9

B-7. RUNOFF

Runoff studies for the drainage areas behind the recommended protective works at Stratford were predicated on a 10-year, 6-hour rainfall applied coincident with a design tidal-flood level of 13.2 feet msl. A runoff hydrograph for the 1,330 acre drainage area above the Broad Street crossing of Ferry Creek was derived by the synthetic unit graph method in which the rainfall was applied to the respective one-half-hour unit hydrograph after deducting infiltration losses of 0.04 inch per hour. The estimated runoffs from the remaining sub drainage areas behind the protection and the peak rates of inflow to the several individual ponding areas were developed from the rational formula Q=CIA with "C" values ranging between 0.5 and 0.9. The peak inflows and total runoff from the 6-hour rainfall for the several ponding areas are given in Table B-5.

HYDRAULICS

B-8. HURRICANE OR STORM-TIDE FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations in Stratford and other Connecticut coastal areas during Hurricane Carol (1954) were obtained during the course of damage-survey work in the field. The elevations of these flood levels, referred to mean sea level, were then determined by a field level party. This information was supplemented by high water levels collected by this office after the September 1938 hurricane. Based on this information, profiles have been prepared of the 1938 and 1954 tidal-flood elevations between Willets Point, New York, at the western end of Long Island Sound, and Wareham, Massachusetts, at the eastern end of Buzzards Bay. A map and profile for the coastline between Westport and Branford, Connecticut, are included with this report. See Plates B-1 and B-2. For the Stratford area, at approximately Mile 43.0 on the profile, a general level of 9.2 feet msl is indicated for both the 1938 and 1954 hurricanes. Tide curves for the 1938, 1944, and 1954 hurricanes are shown on Plate B-3.

The tidal elevation-frequency curve for Stratford is based on (1) observed tidal-flood elevations at Stratford for the 1938 and 1954 hurricanes and, (2) tidal elevation-frequency data for Bridgeport Harbor. Tidal elevation-frequency data for Stratford is shown in Table B-6. The Stratford frequency curve, see Plate B-4, represents a composite curve based on 147-year period, 1815-1961, that influences the upper portion of the curve and a 24-year period, 1938-1961, for which there is a continuous tide gage record, that determines the lower portion of the curve.

TABLE B-5

INTERIOR RUNOFF - 10-YEAR, 6-HOUR RAINFALL

HURRICANE PROTECTION PLAN

Stratford, Connecticut

Ponding Area	Drainage Area (acres)	Peak Inflow (cfs)	Total Runoff (ac. ft.)
Great Meadows Protection			
Area 1 - Turnpike to Lordship	2180	1750	528
Housatonic River Protection			
Area 7 - Lordship to Sniffen's Lane	52	104	13
Area 6 - Avco Plant	60	216	15
Area 5 - Avco to Birdseye St.	50	100	12
Area 4 - Birdseye St. to South Ave.	96	154	23
Area 3 - Selby Pond	65	146	16
Area 2 - Ferry Creek north of Broad St.	1330	980	361

TABLE B-6

TIDAL ELEVATIONS VS FREQUENCY DATA

HURRICANES AND SEVERE STORMS

Stratford, Connecticut

Hurricane or Storm	Estimated Maximum Tidal Elevation (2) (ft. msl)	Frequency Plotting Position(1) Percent Chance of Occurrence in any one Year. 1815-1961	1938-1961
Hurricane, 23 Sept. 1815	9.2	0.34	
Hurricane, 24 Aug. 1893	9.2	1.02	
Hurricane, 21 Sept. 1938	9.2 (3)	1.70	2.1
Hurricane, 31 Aug. 1954	9.2 (3)	2.38	6.2
Hurricane, 14 Sept. 1944	8.8 (3)		10.4
Storm, 25 Nov. 1950	8.8		14.6
Storm, 7 Nov. 1953	8.6		18.8
Hurricane, 12 Sept. 1960	8.2		22.9
Storm, 14 Oct. 1955	7.9		27.1
Storm, 19 Feb. 1960	7.9		31.2
Storm, 13 Apr. 1961	7.7		35.4
Storm, 30 Nov. 1944	7.4		39.6
Storm, 16 Feb. 1958	7.3		43.8
Storm, 20 Mar. 1958	7.3		47.9
Hurricane, 21 Sept. 1961	7.3		52.1
Storm, 31 Oct. 1947	7.2		56.2
Storm, 12 Mar. 1959	7.2		60.4
Storm, 14 Feb. 1960	7.2		64.6
Storm, 9 Mar. 1961	7.1		68.8
Storm, 27 Nov. 1940	6.8		72.9
Storm, 29 Nov. 1945	6.8		77.1
Storm, 8 Dec. 1950	6.8		81.2
Storm, 4 Feb. 1961	6.8		85.4
Storm, 23 Oct. 1961	6.8		89.6
Storm, 28 Feb. 1958	6.7		93.8
Storm, 4 May 1954	6.6		97.9
Storm, 21 Apr. 1940	6.6		100.0

(1) Calculated Plotting Position:- $P = \frac{100\ (M-0.5)}{Y}$, where

P = percent chance of occurrence in any one year
M = number of the event
Y = number of years of record

(2) Based on tidal elevation data for Bridgeport; 1815 and 1893 estimated from historical accounts, others from tide gage readings.

(3) Based on high water marks at Stratford.

B-9. STANDARD PROJECT HURRICANE STORM-TIDE DERIVATION

The design surge at Stratford is based on surge calculations for Long Island Sound made by the Department of Oceanography of the Agricultural and Mechanical College of Texas under contract with the Beach Erosion Board. The evaluation of Standard Project storm surges for Long Island Sound was made by verification of analytical computations with information on observed high water levels in the Sound during the 1938 hurricane. The wind and barometric pressure patterns utilized in the 1938 hurricane problem were taken from U. S. Weather Bureau Memorandum HUR 7-8 dated 1 June 1956. Computations were made for hurricanes advancing at speeds of 30 to 40 knots. From a surge viewpoint, the latter condition is most critical for the eastern and western portions of the sound, and the 30-knot hurricane, the most critical for the central portion. The Standard Project Hurricane corresponds to a transposition of the 1944 hurricane which was especially severe off Cape Hatteras, with wind field and pressures as specified in U. S. Weather Bureau Memoranda Nos. HUR 7-13 and 7-21, dated 1 August 1956 and 23 January 1957. This hurricane was considered to move northward along a path that would cause the region of maximum winds and highest surge to be directed into the eastern entrance of the Sound, off Montauk Point, Long Island. At Stratford, to allow for the differences between observed and computed surges in the 1938 hurricane, the computed Standard Project Hurricane surge for the 30-knot storm was modified by the ratio of the observed to the computed 1938 surge. This gave a Standard Project Hurricane surge of 9.0 feet for Stratford, or 1.35 times the experienced surge of 6.7 feet in the 1938 hurricane.

B-10. DESIGN TIDAL-FLOOD LEVEL

The design tidal-flood level at Stratford has been determined by adding the surge in a Standard Project Hurricane to a mean spring high water elevation of 4.2 feet msl. This gives a design stillwater level of 13.2 feet msl, derived as follows:

Surge, Standard Project Hurricane	9.0 feet
Mean spring high water	4.2 feet msl
Design tidal-flood level	13.2 feet msl

B-11. DESIGN WAVES

Significant wave heights as indicated below have been estimated for the following locations in Stratford at the time of a design hurricane.

a. Long Beach. Computations based on a fetch of 16.0 nautical miles and winds from the southwest quadrant, with velocities ranging from 65 mph at time of peak flooding to 40 mph two hours after the peak, indicate that the significant wave off the shore would range from 6.0 to 9.0 feet in height with periods of 5.0 to 7.0 seconds, respectively, with the lesser wave being experienced coincident with the peak flooding. The maximum wave that would break upon the dike structure in this area, as determined by depth limitations at the toe of the dike, would range from one 7.0 feet in height at and west of the dike crossing of Lewis Gut, assuming 4.6 feet of erosion at Long Beach, to one 8.0 feet in height east of the crossing, assuming 2.0 feet of erosion.

b. Johnsons Creek. The 6.0 to 8.0-foot significant wave in Long Island Sound, at and near the time of peak flooding, refracted through Bridgeport Harbor and diffracted through the entrance to Johnsons Creek results in a 2.0-foot significant wave along the shore of Johnsons Creek at the entrance to Lewis Gut.

c. Long Island Sound, north of Stratford Point. The maximum significant wave to be anticipated along this shore, based on a fetch of about 40 nautical miles and a wind velocity of 65 mph from the northeast quadrant, is one of 10.0-foot height and 7.0-second period. It would be experienced about two hours before the time of peak flooding. Depth limitations would reduce this 10.0-foot wave to one of 5.0-foot height at the head of the marine basin and from zero to approximately one foot along the dikes extending north and south from the basin.

At and near the time of peak flooding, when the design hurricane winds would be from the southwest quadrant, the diffracted wave around Stratford Point, from Long Island Sound, would be about 5.0 feet in height. Depth limitations at this time, with the flood level at 13.2 feet msl, would limit the size of the wave breaking on the dike to a height of 2.0 feet south of the marine basin and to a height of 2.0 to 3.0 feet between the marine basin and the Housatonic River.

d. Avco dike. Predicated on a 65 mph wind from the northeast quadrant and a fetch of 2.0 miles, it is estimated that this dike would experience a 3.0-foot wave about two hours before the time of peak flooding in a design hurricane. A diffracted wave around Stratford Point, from Long Island Sound, would result in a wave approximately 2.0 feet high at the time of peak flooding.

e. Housatonic River above Avco dike. It is anticipated that waves up to 2.0 feet in height would break upon the protection.

B-12. WAVE RUNUP AND OVERTOPPING

The amount of overtopping is important not only in the design of a safe structure but also from the standpoint of flooding that may be caused by the ponding of the overtopping water. Rates of overtopping were determined for a peak stillwater level of 13.2 feet msl. The heights of a significant wave in the project hurricane, shown in Table B-7, as restricted by depth limitations, were used in the computations. The amount of overtopping was calculated by a mehod derived by the Beach Erosion Board staff and was determined for one-half hour time intervals for an estimated overtopping duration of 1.5 hours.

Overtopping data were obtained by interpolation and extrapolation of the curves in the Beach Erosion Board Technical Memorandum No. 64 entitled "Laboratory Data on Wave Run-up and Overtopping on Shore Structures." Since the wave heights in a wave train vary considerably from wave to wave, it was necessary to determine partial values of overtopping associated with each height in the wave spectrum. These values were then weighted according to the relative frequency of occurrence of the particular height and then summed for the final value of overtopping associated with a wave train of significant height.

Wave run-up data were obtained from the Beach Erosion Board Technical Report No. 4, to determine the lower limit of wave height for which overtopping occurs. Waves that broke seaward of the structure, due to shallow depths, were assumed to reform into lower waves. These waves were redistributed throughout the rest of the height groups according to the proportion of the total number of waves in the group.

The top of maximum run-up and the amounts of overtopping that would pond in various areas behind the proposed protection during a design hurricane are given in Table B-7.

B-13. PONDING AND PUMPING

The total volume of fresh water runoff that could accumulate in the several ponding areas behind the proposed protection in the event of a 10-year, 6-hour rainfall are summarized in Table B-8. The peak levels of ponding that would be caused by the combination of wave overtopping in a design hurricane and interior runoff are given in Table B-8. These levels have been determined from area-capacity curves shown on Plates B-6, B-7, and B-8, and on the basis that all openings through the protection would be closed when the flood tide is at a stage of zero feet msl. The area-capacity curves are based

TABLE B-7

WAVE RUNUP AND OVERTOPPING

HURRICANE PROTECTION PLAN

Stratford, Connecticut

Location	Top Elev. (ft.msl)	Toe Elev. (ft.msl)	Sig. Wave (ft.)	Top of Maximum Runup (ft.msl)	Overtopping (1) Max. Rate (cfs)	Overtopping (1) Total Volume (ac.ft.)
Great Meadows Protection						
Turnpike to Lewis Gut						
Sta. 0+00 to 11+30	14.0	6.0	1.0	15.9	167	21
Sta. 11+30 to 35+00	14.0	8.0	-	-	-	-
Sta. 35+00 to 57+00	14.5	4.5	2.0	17.0	557	70
Lewis Gut and Long Beach						
Sta. 57+00 to 69+00	15.5	3.5	4.0	18.9	230	29
Sta. 69+00 to 99+00	15.5	10.0(2)	6.0-7.0	17.0	292	37
Sta. 99+00 to 111+30	17.0	8.5	7.0	17.8	45	6
Sta. 111+30 to 143+30	18.0	4.8(3)	8.0	19.5	266	45
Sta. 143+30 to 150+30	16.0	5.0	5.0	19.3	179	22
Sub-Total						230
Housatonic River Protection						
Lordship to Sniffen's Lane						
Sta. 0+00 to 22+00	16.5	10.5	5.0	16.8	-	minor
Sta. 22+00 to 26+50	18.0	3.0	5.0	20.0	47	6
Sta. 26+50 to 43+50	16.5	6.0(4)	5.0	17.3	31	4
Sub-Total						10
Air Force Plant 43 (Avco)						
Sta. 43+50 to 45+00	15.5	12.5	-	15.3	-	minor
Sta. 45+00 to 70+00	16.5	0.0	2.0	16.3	-	minor
Sta. 70+00 to 73+00	16.0	6.0	2.0	16.9	7	1
Sub-Total						1

TABLE B-7 (Cont'd)

Location	Top Elev. (ft.msl)	Toe Elev. (ft.msl)	Sig. Wave (ft.)	Top of Maximum Runup (ft.msl)	Overtopping (1) Max. Rate (cfs)	Overtopping (1) Total Volume (ac.ft.)
Housatonic River Protection (Cont'd)						
Avco Plant to South Ave.						
Sta. 73+00 to 83+80	16.0	6.0	2.0	-	-	-
and 87+80 to 95+30	16.0	6.0	2.0	16.9	42	5
Sta. 83+80 to 87+80	14.0	12.0	2.0	15.8	-	minor
Sta. 95+30 to 97+30	15.5	11.0	2.0	16.4	13	2
Sta. 97+30 to 99+10	15.5	7.5	2.0	-	-	-
and 0+00 to 3+20 (5)	15.5	3.5	2.0	16.9	40	5
Sta. 99+10 to 104+70	14.0	12.0	2.0	15.8	-	minor
Sub-Total						12
Selby Pond Area (North of Stratford Ave.)						
Sta. 0+00 to 6+00	15.5	6.5	2.0	16.9	43	5
Sub-Total						5
Ferry Creek at Broad St.						
Sta. 6+00 to 11+50	15.5	6.5	2.0	16.9	37	5
260 feet of wall	15.0	11.0	2.0	17.8	20	3
Sub-Total						8

(1) For design hurricane with swl at 13.2 ft. msl.
(2) Elevation of berm
(3) Assumed limit of erosion
(4) Controlling elevation along shore is 9.5 ft. msl.
(5) At tidal inlet south of South Ave.

TABLE B-8

PONDING OF RUNOFF AND OVERTOPPING

HURRICANE PROTECTION PLAN

Stratford, Connecticut

Location	Overtopping Volume (1) (acre-feet)	Runoff Volume (2) (acre-feet)	Ponding Volume (acre-feet)	Ponding Elevation(3) (ft. msl)
Great Meadows Protection	230	528	758	3.9
Housatonic R. Protection				
Lordship to Sniffen's Lane	10	13	23	6.2
Air Force Plant 43 (Avco)	1	15	(4)	-
Avco to South Ave.	12	35	41(5)	6.5
Selby Pond	5	16	21	7.0
Ferry Creek at Broad St.	8	361	53(6)	7.2

Notes

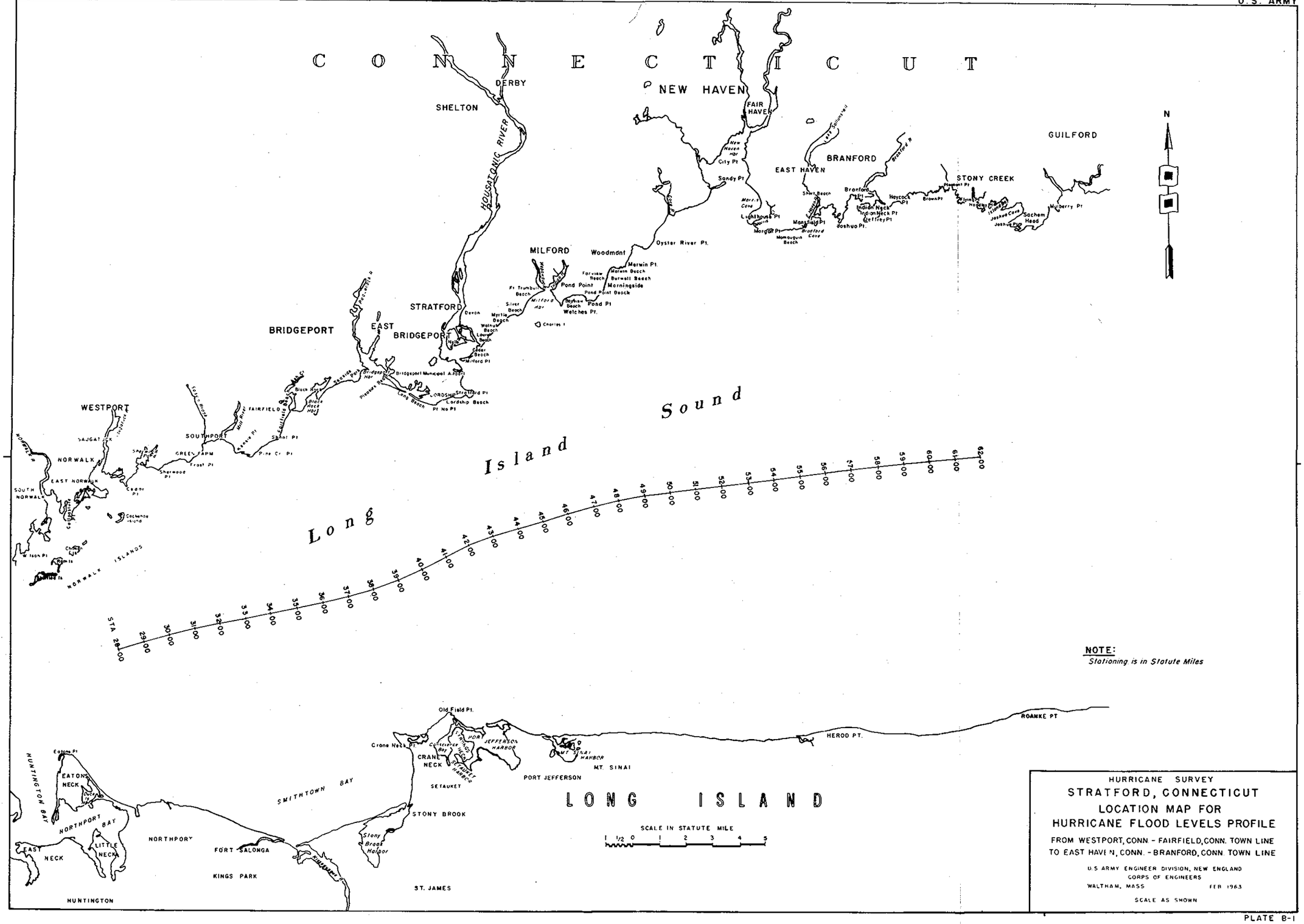
(1) For design hurricane; swl at 13.2 ft. msl
(2) Total for 10-year, 6-hour rainfall
(3) Based on closing of all openings when tide is at 0.0 ft. msl
(4) No ponding with 220 cfs of pumping
(5) With 20 cfs of pumping
(6) With 600 cfs of pumping

on U. S. Geological Survey maps supplemented by available town maps and topographic data secured in connection with the present investigation of the tidal-flood problem at Stratford. The area-capacity curve for the area behind the Great Meadows protection is based on the assumption that 300 acres of water and marshes, south of Great Meadow Road and above the proposed barrier crossing of Lewis Gut, would be reserved for ponding with the remainder of the area south of Great Meadows Road eventually being raised and utilized by industry.

The levels of ponding in the areas behind (1) the Great Meadows protection, (2) the diking between Lordship and Sniffen's Lane, south of the Avco Plant, and (3) the protection in the Selby Pond area would in all three cases be below the stages where flood damages would begin. Ponding in the area behind the protection in the vicinity of the sewage treatment plant, between the Avco Plant and South Ave., would be limited to a level of approximately 6.5 feet msl, or 0.3-foot above the stage of zero damage, by the provision of 20 cfs of capacity in a pumping station at the treatment plant. This pumping station would also include 30 cfs of capacity to discharge the sewage effluent during a storm. Relatively little storage is available in the ponding area of Ferry Creek above Broad Street. A pumping station with a capacity of 600 cfs would be required at Broad Street to keep the ponding of runoff and overtopping in this area from exceeding a level of 7.2 feet msl, a stage that is one foot above the stage where damage begins. Above a level of 7.2 feet msl, damages in the Ferry Creek area mount rapidly, increasing by nearly $200,000 with a one-foot rise in stage. The damages from ponding in both the treatment plant and Ferry Creek areas, at levels as shown in Table B-7, would be relatively minor and, moreover, would only occur upon the very rare occurrence of the coincidence of peak tidal-flooding in a project hurricane with a 10-year rainfall. At Air Force Plant 43 (Avco) no storage of consequence is available and a pumping capacity of 220 cfs is required to prevent the ponding of combined runoff and overtopping at this plant under design rainfall and hurricane conditions.

CORPS OF ENGINEERS

U.S. ARMY



NOTE:
Stationing is in Statute Miles

HURRICANE SURVEY

STRATFORD, CONNECTICUT

LOCATION MAP FOR HURRICANE FLOOD LEVELS PROFILE

FROM WESTPORT, CONN. - FAIRFIELD, CONN. TOWN LINE
TO EAST HAVEN, CONN. - BRANFORD, CONN. TOWN LINE

U.S ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS FEB 1963

SCALE AS SHOWN

PLATE B-1

CORPS OF ENGINEERS

U. S. ARMY

CONNECTICUT

WESTPORT | FAIRFIELD | BRIDGEPORT | STRATFORD | MILFORD | WEST HAVEN | NEW HAVEN | EAST HAVEN | BRANFORD

SASCO BROOK · MILL RIVER · KENSIE POINT · PINE CREEK POINT · FAIRFIELD BEACH · SHOAL POINT · FAIRFIELD BEACH · ASH CREEK · BLACK ROCK HARBOR · SEASIDE PARK · BRIDGEPORT HARBOR · PLEASURE BEACH · LONG BEACH · POINT NO POINT · LORDSHIP BEACH · STRATFORD POINT · MILFORD POINT · LAUREL BEACH · WALNUT BEACH · MYRTLE BEACH · SILVER BEACH · FT TRUMBULL BEACH · MILFORD HARBOR · WEPAWAUG RIVER · HOOKS RIVER · WELCHES POINT · BAYVIEW BEACH · POND POINT · MORNINGSIDE BEACH · FELLOWS BEACH · BURWELL BEACH · MERWIN BEACH · MERWIN POINT · WOODMONT · OYSTER RIVER POINT · COVE RIVER · CITY POINT · SANDY POINT · NEW HAVEN HARBOR POINT · MORRIS CREEK · MORGAN POINT · MOMAUGUIN BEACH · BRANFORD POINT · BRANFORD COVE · EAST HAVEN RIVER

STANDARD PROJECT HURRICANE TIDAL FLOOD

HURRICANE OF SEPTEMBER 21, 1938 TIDAL FLOOD

HURRICANE CAROL, AUGUST 31, 1954 TIDAL FLOOD

MEAN SPRING HIGH WATER

MEAN HIGH WATER

MEAN SEA LEVEL

MEAN LOW WATER

SEPTEMBER 21, 1938 HIGH WATER

AUGUST 31, 1954 HIGH WATER

855 NUMBER IDENTIFIES HIGH WATER MARK

ELEVATION IN FEET ABOVE MEAN SEA LEVEL

STATUTE MILES — LONG ISLAND SOUND

35 40 45 50 55 60

HURRICANE SURVEY

STRATFORD, CONNECTICUT

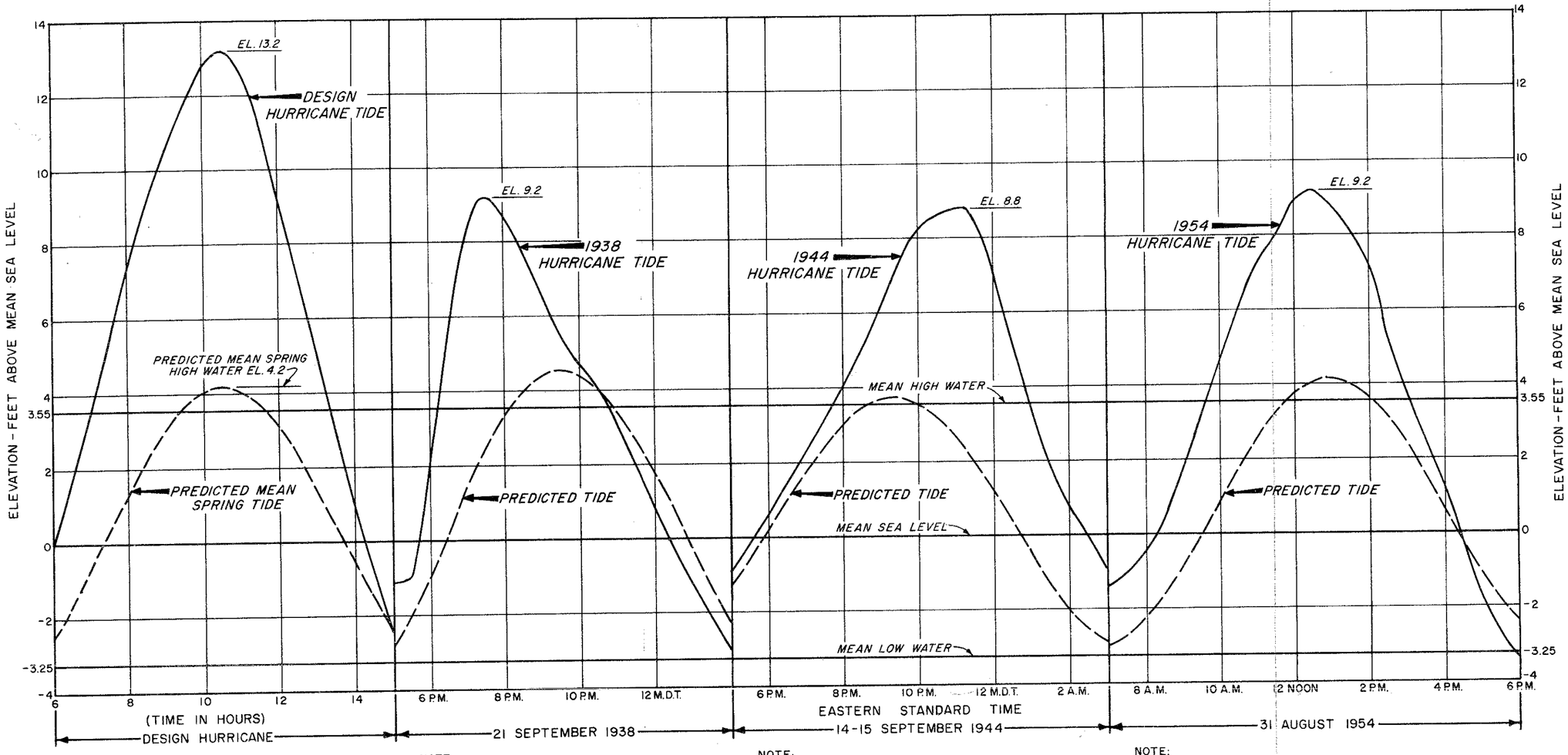
HURRICANE FLOOD LEVELS PROFILE

FROM WESTPORT, CONN. - FAIRFIELD, CONN. TOWN LINE

TO EAST HAVEN, CONN. - BRANFORD, CONN. TOWN LINE

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB 1963
SCALE AS SHOWN

PLATE B-2



NOTE:
Design hurricane tide curve based on Texas A. & M. surge calculations for a design storm with a track most critical to Long Island Sound and with the peak of the surge coincident with the peak of a predicted mean spring tide.

NOTE:
Hurricane of September 21, 1938 tide curve based on high water marks in the vicinity of Stratford and hurricane tide at Willets Point, N.Y. stage related to Stratford.

NOTE:
Hurricane of September 14-15, 1944 tide curve based on high water marks in the vicinity of Stratford and hurricane tide at New London, Conn. stage related to Stratford.

NOTE:
Hurricane Carol, August 31, 1954 tide curve based on high water marks in the vicinity of Stratford and hurricane tide at Bridgeport, Conn. stage related to Stratford.

HURRICANE SURVEY

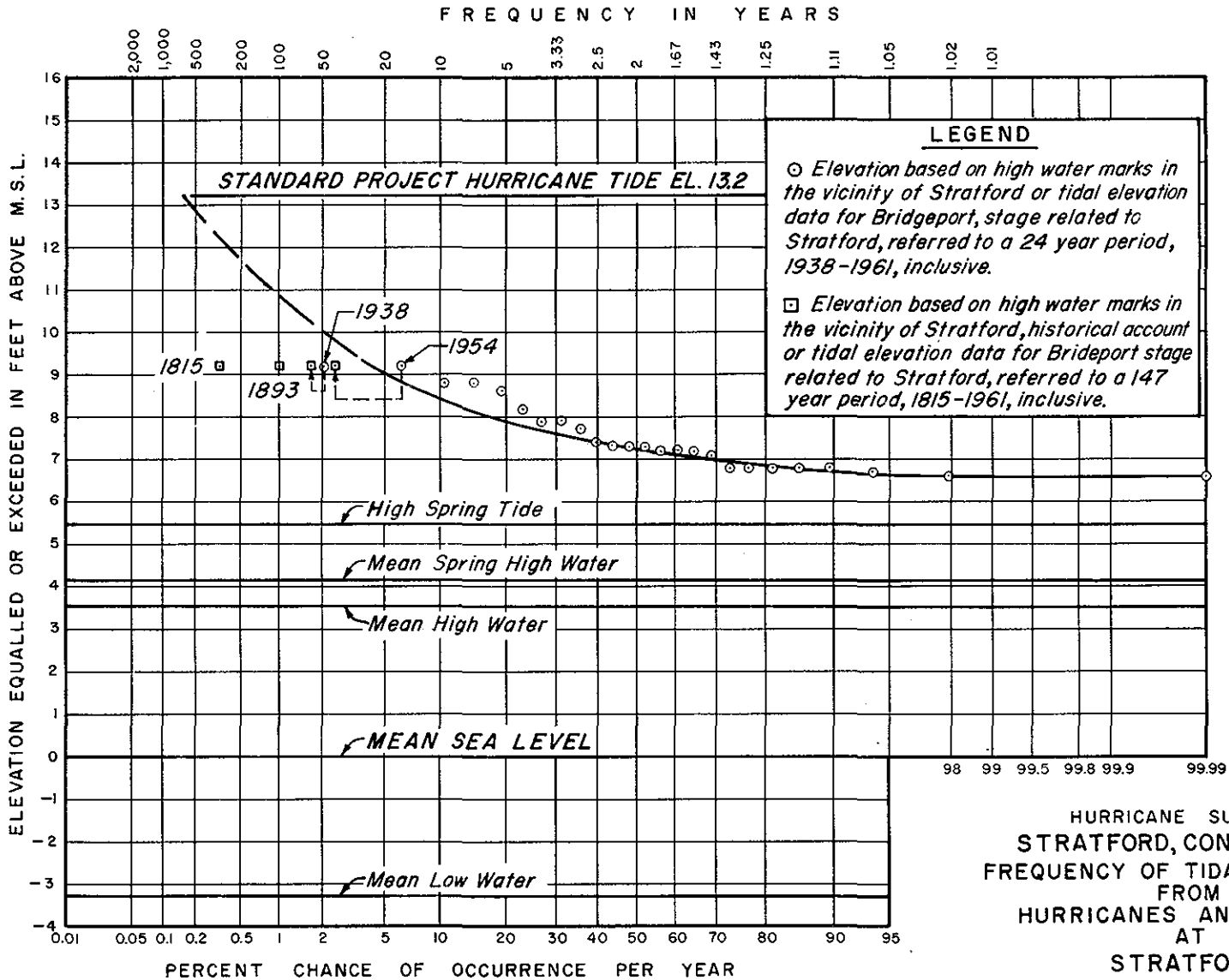
STRATFORD, CONN.

TIDE CURVES

DESIGN, 1938, 1944 & 1954 HURRICANES

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1963

PLATE B-3



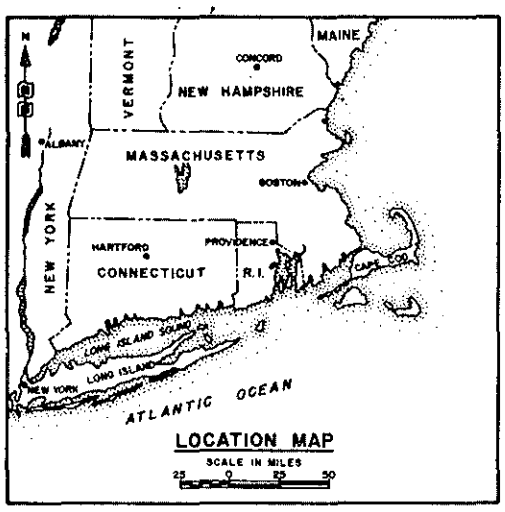
HURRICANE SURVEY

STRATFORD, CONNECTICUT

FREQUENCY OF TIDAL FLOODING FROM HURRICANES AND STORMS AT STRATFORD

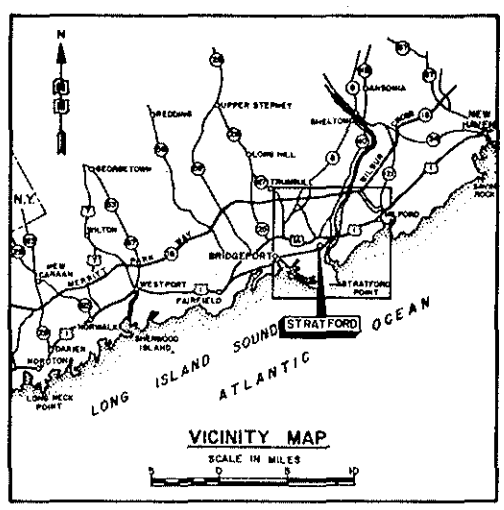
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1963

PLATE B-4



LOCATION MAP

SCALE IN MILES 25 0 25 50



VICINITY MAP

SCALE IN MILES 0 5 10

LEGEND:

AREA (NO.)	DRAINAGE AREA (ACRES)
1 GREAT MEADOWS	2180
2 FERRY CREEK	1330
3 SELBY POND	65
4 SOUTH AVENUE	96
5 SEWAGE TREATMENT PLANT	50
6 AVCO PLANT	60
7 MARINE BASIN	52

SCALE IN FEET 1000 0 1000 2000

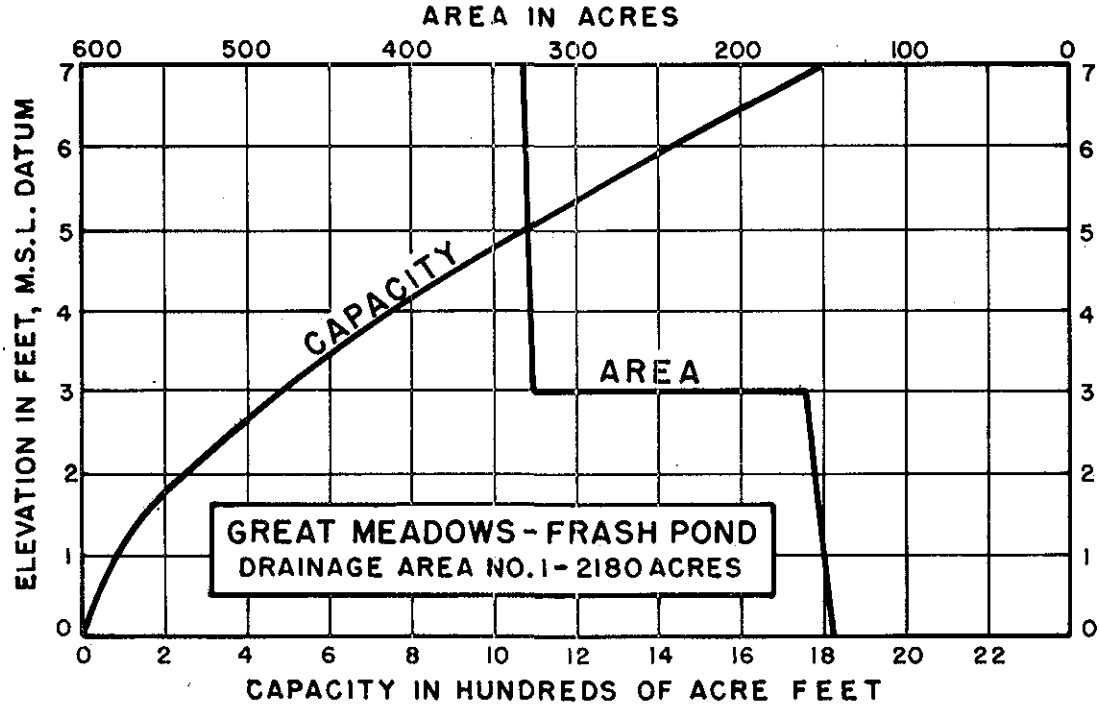
HURRICANE SURVEY

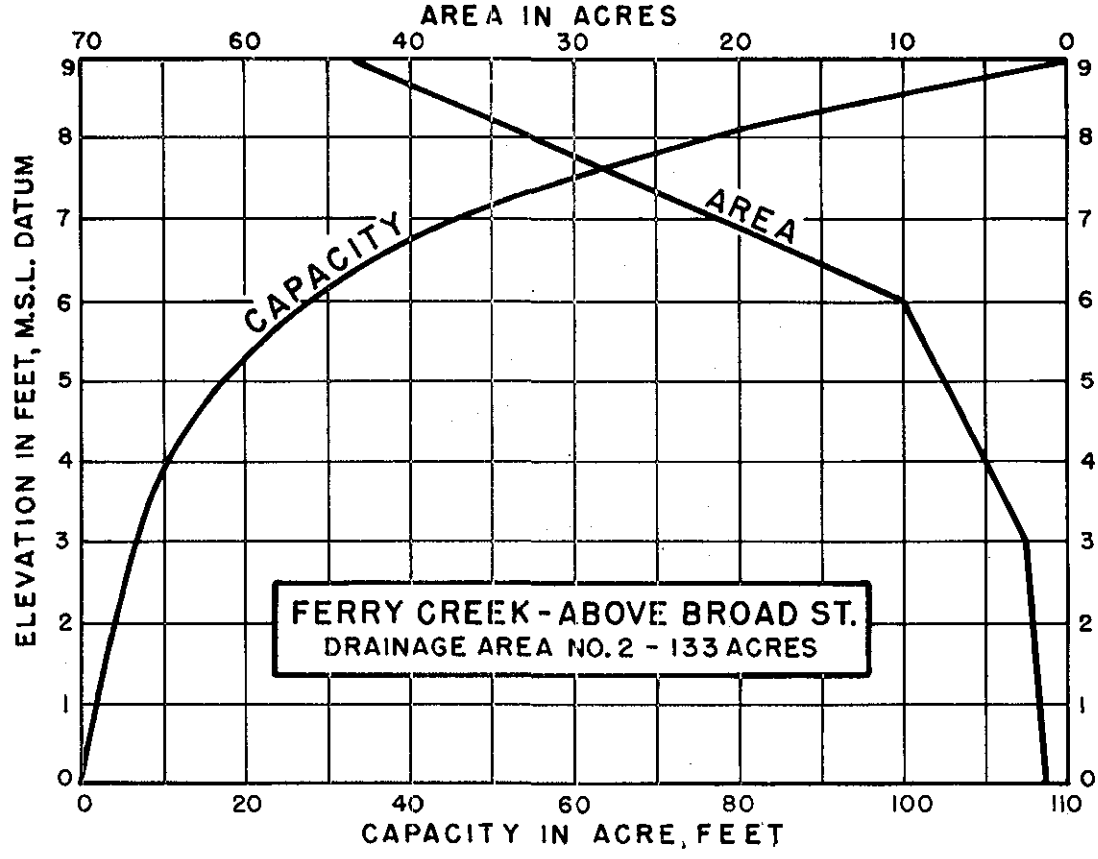
STRATFORD, CONNECTICUT

DRAINAGE AREAS CONTRIBUTING RUN-OFF TO PROTECTED AREA

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1963
SCALE AS SHOWN

PLATE B-5

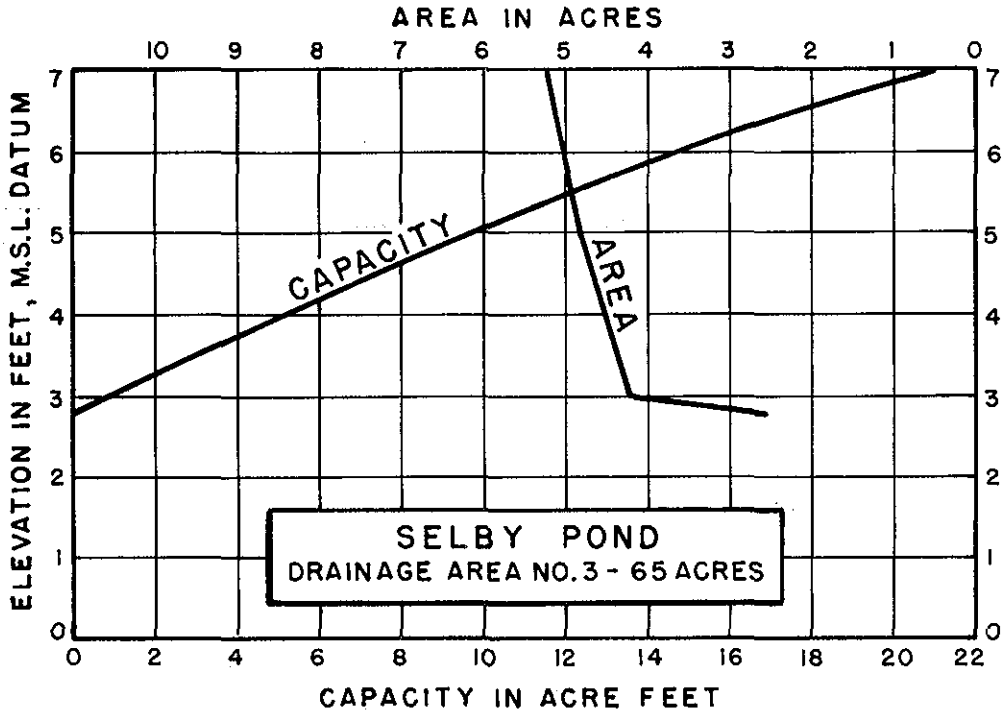


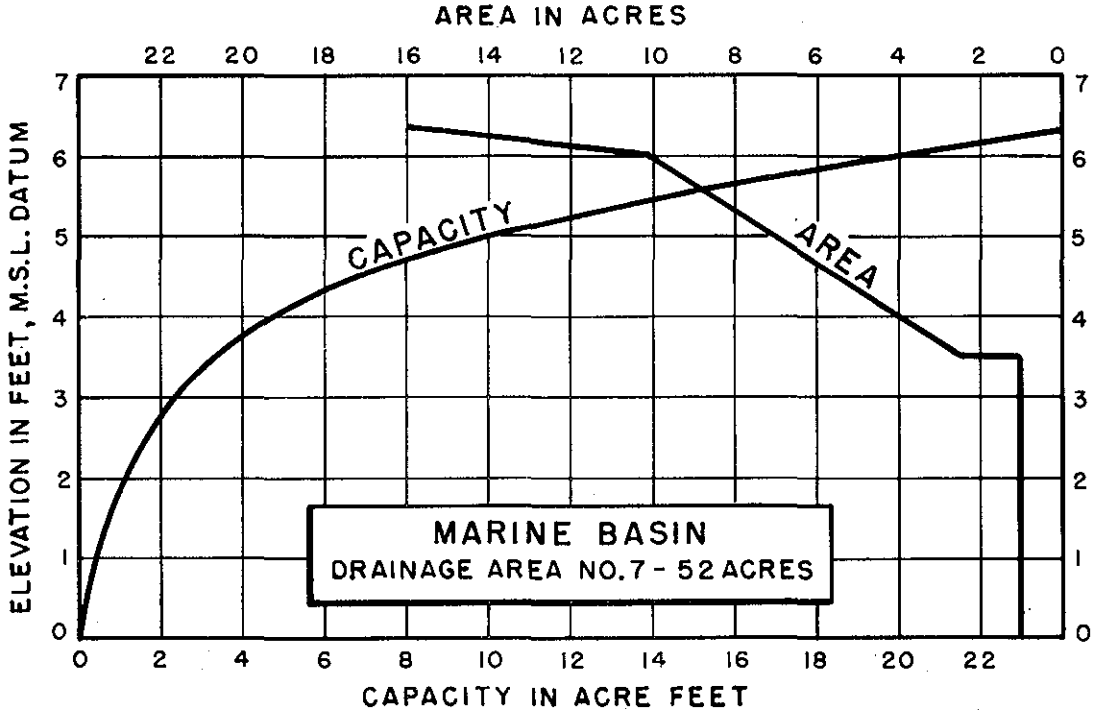


HURRICANE SURVEY
STRATFORD, CONNECTICUT
AREA AND CAPACITY CURVES
SCALE AS SHOWN
FEB. 1963

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS, WALTHAM, MASS.

PLATE B-6

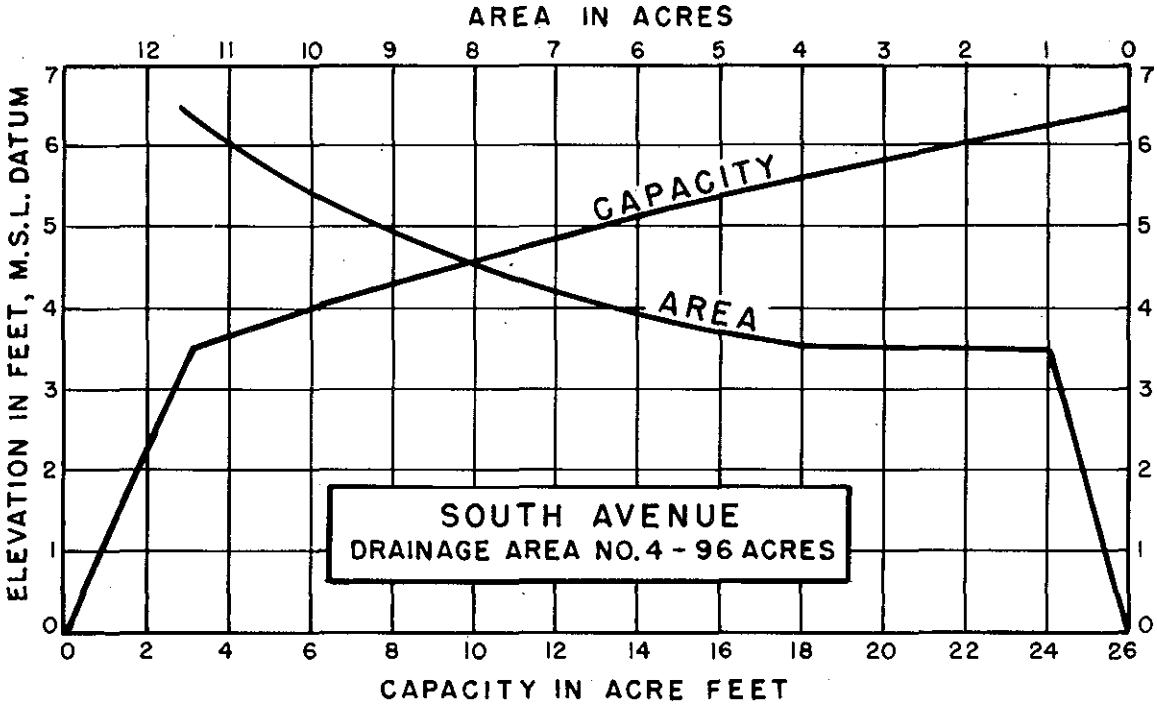


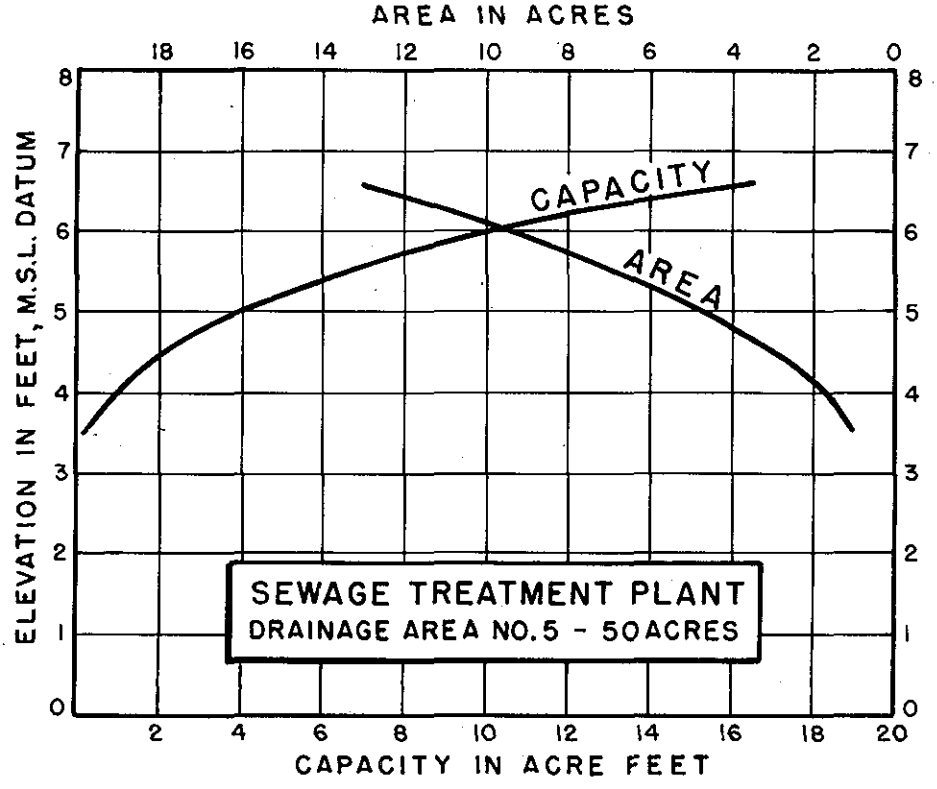


HURRICANE SURVEY
STRATFORD, CONNECTICUT
AREA AND CAPACITY CURVES
SCALE AS SHOWN
FEB. 1963

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS, WALTHAM, MASS.

PLATE B-7





HURRICANE SURVEY
STRATFORD, CONNECTICUT
AREA AND CAPACITY CURVES
SCALE AS SHOWN
FEB. 1963

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS, WALTHAM, MASS.

PLATE B-8

APPENDIX C

FLOOD LOSSES AND BENEFITS

APPENDIX C

FLOOD LOSSES AND BENEFITS

TABLE OF CONTENTS

Paragraph	Title	Page
	GENERAL	
C-1	Damage Surveys	C-1
C-2	Loss Classification	C-1
	HURRICANE TIDAL FLOOD DAMAGES	
C-3	Tidal Flood Losses	C-2
C-4	Types and Distribution of Experienced Losses	C-2
C-5	Recurring Losses	C-2
C-6	TRENDS OF DEVELOPMENT	C-3
	ANNUAL LOSSES AND BENEFITS	
C-7	General	C-4
C-8	Average Annual Tidal Flood Losses	C-5
C-9	Annual Damage Prevention Benefits	C-5
C-10	Benefits From Prevention of Emergency Costs	C-5
C-11	Increased Utilization Benefits	C-6
	a. General	C-6
	b. Development of Land	C-7
	c. Value of Land	C-7

APPENDIX C (Cont'd)

TABLES

Number	Title	Page
C-1	Population Data	C-3
C-2	Increased Utilization Benefits From Hurricane Protection - Great Meadows Area	C-8

PLATES

Number	Title
C-1	Flood Area and Damages
C-2	Stage-Damage Curve: below Selby Pond
C-3	Damage-Frequency Curve: below Selby Pond

APPENDIX C

FLOOD LOSSES AND BENEFITS

GENERAL

C-1. DAMAGE SURVEY

A damage survey of the Long Island Sound and Housatonic River tidewater areas of Stratford was made in the fall of 1956 and reviewed in recent months. The survey consisted largely of door-to-door interviews and inspections of the various residential, commercial, public, and industrial properties in the flooded areas of the town. Information obtained included the extent of areas flooded, descriptions of properties, including economic and physical changes since the 1954 hurricane, the nature and amount of damages, depths of flooding, high-water references, and relationships between the August 1954 flood level and other tidal-flood stages. Damage estimates and depths of tidal flooding were generally furnished by property owners or tenants. Investigators prepared alternate estimates when, in their judgment, estimates of owners or tenants were unrealistic or unreliable. The investigators also made estimates where information was not available from owners or tenants. Sampling methods were used where several properties of similar type were subject to the same depth of flooding. A consolidated report on damages to public property, utilities, and highways was obtained from town officials and applied to the field information. The review survey was concerned principally with changes in use of previously surveyed properties, changes in business activities in the larger industrial plants covered in the original survey, and new properties in the flood area since the original survey.

Sufficient data were obtained to derive loss estimates for (1) the August 1954 flood stage, (2) a stage 3 feet higher, and (3) intermediate stages where marked increases in damage occurred. The stage at which damage begins, referenced to the August 1954 flood stage, was also determined.

C-2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and location. The types of losses recorded included urban (residential and commercial), industrial, and public (streets, utilities, airport).

Primary losses were evaluated, including (1) physical losses, such as damage to structures, machinery, equipment and stock, and cost of cleanup and repairs, and (2) nonphysical losses, such as unrecoverable losses of business and wages, increased cost of operation, and the cost

of temporary facilities. Physical losses and a large part of the related nonphysical losses were determined by direct inspection of flooded properties and evaluation of the losses by property owners or field investigators or both. Occasionally the nonphysical portions of the primary losses were difficult to estimate due to lack of information. Where this condition existed, the nonphysical losses were estimated by utilizing determined relationships between physical and nonphysical losses for similar properties in the survey and other areas.

No evaluation was made of intangible losses including items such as possible loss of life, hazards to health, and detrimental effects on the national security.

HURRICANE TIDAL FLOOD DAMAGES

C-3. TIDAL FLOOD LOSSES

The hurricane tidal surge accompanying Hurricane Carol on 31 August 1954 occurred nearly coincident with the peak of a high gravitational tide and caused serious flooding in the Town of Stratford. Tidal flooding in 1954 rose approximately 6.0 feet above mean high water, reaching a level of 9.2 feet msl, the same level as experienced in 1938. The tidal flood damages in Stratford, in August 1954, amounted to $1,043,000. Over 750 structures, the airport, and the sewage treatment plant suffered flood damages. The flooded area of the town in 1954 is shown on Plate C-1.

C-4. TYPE AND DISTRIBUTION OF EXPERIENCED LOSSES

Industrial plants, situated mainly in the flooded area along the west bank of the Housatonic River, suffered almost one-half of the total tidal flood losses experienced in Stratford during Hurricane Carol in 1954. The total damages to industrial plants in the town at that time amounted to $512,000.

Urban losses, mainly residential in nature, amounted to $429,000 in 1954. The bulk of these losses were suffered in the built-over area of the town, northwest of the airport, as the flood waters from Long Island Sound inundated the lower portion of Stratford to points about two miles inland from the southern shore line of the town.

The public losses in 1954 amounted to over $100,000 with the greatest part of this total, $70,000, being suffered by the Bridgeport Municipal Airport.

C-5. RECURRING LOSSES

The recent review survey found that (1) an increase in plant

investment and economic activity had taken place at most of the industrial plants which had suffered losses in the 1954 flood, and (2) a number of new industries, mostly small, had located in the flood area of the town since Hurricane Carol. A recurrence of the 1938 and 1954 tidal flood stage of 9.2 feet msl would today cause losses in Stratford estimated at $1,531,000. Of this total, $1,361,000 would occur in the area behind the proposed protection and would be eliminated by construction of the plan. In the event of flooding to a stage two feet above the record 1938 and 1954 level the damages would approximate $22,000,000 under existing conditions.

TRENDS OF DEVELOPMENT

C-6. The Town of Stratford has experienced a rapid increase in population over the past 20 to 30 years, doubling in size during the period from 1940 to 1960. The rate of the population growth in the town for the decade ending in 1960 was higher than the rate for either Fairfield County or the State. Approximately 65 percent of the area of Stratford was classified as urbanized in the 1950 census; by 1960 the entire town was designated an urbanized area by the Bureau of the Census of the United States Department of Commerce. The population changes in Stratford, in Fairfield County, the fastest growing county in the State, and in Connecticut as a whole, since 1930, are shown in the following table.

TABLE C-1

POPULATION DATA
(1930 to 1960)

Stratford, Fairfield County, and State

	1930	1940	1950	1960
Stratford	19,212	22,580	33,428	45,012
% of 1930 population	100%	118%	174%	234%
Fairfield County	386,702	418,384	504,342	653,589
% of 1930 population	100%	108%	130%	169%
State of Connecticut	1,606,903	1,709,242	2,007,280	2,535,234
% of 1930 population	100%	106%	125%	158%

The economic growth of Stratford has paralleled its population growth. The 1954 Directory of Connecticut Manufacturing and Mechanical Establishments, published by the Connecticut Labor Department, lists 65 industrial enterprises in Stratford; the 1960 edition of the same directory lists 92 such establishments. Additional industry has become established in the town since the 1960 directory, covering the period through 1959, was compiled. Industrial development is taking place at the present time in the flood prone portion of Stratford lying north of Great Meadows Road, especially in the Honeyspot Road area. Two new industries have even located in the area to the south of Great Meadows Road.

Great Meadows Road forms the boundary between the areas zoned for light and heavy industry in Stratford with the zone for light industry being on the north side of the road and the zone for heavy industry being to the south. With a continuation of the present trend, the available area on the north side of Great Meadows Road, zoned for light industry, will be completely utilized by light industrial developments by the time hurricane protection is provided. At present, some 64 acres of this area are occupied by light industrial and commercial concerns. One hundred and eight acres of additional land are available for future development. Allowing a factor of 20 percent for small parcels of land or land otherwise unusable, some 86 acres are available for use as sites for future industrial expansion. The area fronting the south side of Great Meadows Road, west of Honeyspot Road, zoned for heavy industry, will also be developed prior to protection. The remainder of the heavy industry zone will be developed only with protection. Because of zoning requirements and the present state of development in the flood prone portion of Stratford, little growth, other than as outlined above, is to be expected in the area behind the planned protection, with one exception.

The Bridgeport Municipal Airport covers over 500 acres that are located east of the heavy industrial zone in the Great Meadows area. A master plan of development for the airport has been prepared which would render the field capable of being used by all but large jet aircraft. Implementation of any portion of the plan, except for the construction of a terminal building and control tower, has been delayed by economic factors and policy decisions. Lacking knowledge of when and how much of the master plan will be implemented, no forecast can be made for this area. However, full development of the airport would substantially increase the damages to be expected in a recurrence of 1954 tidal flood stages.

ANNUAL LOSSES AND BENEFITS

C-7. GENERAL

The benefits to be realized from the control of tidal flooding in

Stratford consist of flood damage prevention benefits, benefits from the elimination of emergency costs, and benefits from increased utilization of land. The flood damage prevention benefits are by far the most important. The benefits of such nature, attributable to the hurricane protection plan at Stratford, have been determined in accordance with standard Corps of Engineers procedures utilizing stage-loss, stage-frequency, and damage-frequency relationships.

C-8. AVERAGE ANNUAL TIDAL FLOOD LOSSES

Recurring tidal flood losses in Stratford have been converted to average annual losses by correlating stage-loss and stage-frequency relationships to derive damage-frequency curves. In the preparation of the stage-loss curve, an allowance was made to cover the future damages to the commercial and industrial facilities which it is anticipated would be established within the areas zoned for light industrial use between 1962 and the time protection is provided. This addition was derived by multiplying the basic stage loss figures for the commercial and light industrial facilities constructed since 1954 by the ratio of the area presently available for the development of light industry (86 acres) to the area (approximately 64 acres) occupied by light industries constructed since 1954.

The stage-loss and stage-frequency curves have been combined to develop damage-frequency curves which have been plotted with damage as the ordinate and percent chance of occurrence (the reciprocal of frequency) as the abscissa. See Plate C-3 for a typical damage frequency curve. The area under this damage-frequency curve is a measure of the average annual loss. The average annual loss in the portion of Stratford to be protected from hurricane tidal flooding amounts to $693,000 at present day price levels. A typical stage-damage curve is shown on Plate C-2. The elevation-frequency curve for Stratford is shown on Plate B-4, Appendix B.

C-9. ANNUAL DAMAGE PREVENTION BENEFITS

The average annual flood damage prevention benefits, attributable to the protection, amount to about $591,000. These benefits, from the prevention of tidal flood damages, have been derived by determining the difference between the average annual losses to be expected at the time construction is started and the average annual losses remaining after construction of the planned protection. The residual damages represent losses that would be experienced with flooding above the design stage of 13.2 feet msl.

C-10. BENEFITS FROM PREVENTION OF EMERGENCY COSTS

In addition to actual tidal flood damages, significant losses are sustained in areas subject to tidal flooding due to the cost of setting

into operation temporary protective measures, following the receipt of hurricane warnings. Based on data gathered in the course of the damage surveys in the Stratford area, it is estimated that emergency costs amounting to $30,000 are incurred by commercial and industrial interests in the town with each hurricane warning. These costs would be eliminated by the proposed protection. Based on a frequency of four hurricane warnings in a 10-year period, the average annual benefit from the elimination of such costs amounts to $12,000.

C-11. INCREASED UTILIZATION BENEFITS

a. General. In the spring of 1962, a field investigation was made of the Great Meadows area of Stratford where it was apparent from the earlier damage surveys that significant benefits would be realized through higher utilization of land made possible by protection against hurricane tidal flooding.

Approximately 310 acres of tidal flats, at elevation between 3.5 feet and 12.0 feet, msl, lying between Great Meadows Road and Long Island Sound, are suitable for industrial development. This tract of land, zoned for heavy industry, is one of the largest so zoned within 15 miles of Bridgeport. The site has ready access to the Connecticut Thruway (Interstate Route I-95) and is conveniently located with respect to railroad and airport facilities. All required utilities are in place at Great Meadows Road.

In the course of the field investigation, useful data was obtained from a number of responsible sources, including town officials, bankers, real estate appraisers, owners of land in the Stratford area, Chamber of Commerce officials, and the Connecticut Development Commission. The study revealed (1) a general need for land which could be developed for heavy industrial use and (2) a specific potential for the land in the Great Meadows area after construction of tidal flood protection works.

The Bridgeport labor market area, of which Stratford is an important and growing segment, is the second largest area in the State of Connecticut. Manufacturing is the largest employer, with 54 percent of the entire labor force, or some 63,000 people. The principal items of local manufacture include fabricated metals, electrical controls and appliances, aircraft engines and parts, and machinery. At present, the largest part of this manufacturing is carried on in plants located in the City of Bridgeport. There is a need for more modern plant facilities to compete in costs with areas more favored in natural resources. This need, together with traffic congestion, has created a demand for new plant sites near the center of the labor market, but in less congested environs. The land in the Great Meadows area of Stratford, located only three miles from the center of Bridgeport, will, with hurricane protection, help to meet this demand.

b. Development of Land. The utilization of much of the land in the Great Meadows for industrial purposes will be gradual because of the time needed for its development. It has been assumed that development of the full potential of this land behind the protection will extend over a 30-year period.

c. Value of Land. For purposes of assessment, the Town of Stratford carries the land on the south side of Great Meadows Road at values ranging from $4,000 an acre for land at a relatively high elevation (10.0 feet, msl, more or less) and fronting on the road, to $200 an acre for the greatest portion of the land which is at lower elevations. Independent appraisals by experts familiar with industrial property values in the Bridgeport area set present values of $6,000 an acre as a reasonable price for the low lying land and up to $9,000 an acre for the higher and better land in the area. Development costs have been computed and added to current sale values to derive base values prior to protection. With protection and development, the land will have a value comparable to that of industrial land north of Great Meadows Road. Recent sales north of Great Meadows have ranged from $13,000 to $17,000 an acre. Based on these figures, a value of $16,000 an acre after protection and development is considered reasonable. The difference in value between the base value and the ultimate value, capitalized at 6 percent, which is the minimum rate of attractive return on real estate in Stratford, represents the enhancement to be realized. The derivation of anticipated increased utilization value is tabulated in Table C-2. The last column in the table represents the average annual equivalent value of the increased utilization after discounting for the time lag in the development.

TABLE C-2

INCREASED UTILIZATION BENEFITS FROM HURRICANE PROTECTION

Great Meadows Area - Stratford, Connecticut

Acres	Present Value (per acre)	Development Costs (per acre)	Total (base) Costs (per acre)	Annual Increased Utilization Benefit (1)	Start of Development (years) (2)	End of Development (years) (2)	Average Annual Equivalent Benefit
80	9,000	4,000	13,000	14,440	1	7	$13,180
20	9,000	5,700	14,700	1,560	7	10	1,220
25	9,000	3,800	12,800	4,800	5	10	3,920
30	7,400	5,335	12,735	5,880	10	15	4,080
115	6,000	9,000	15,000	6,900	15	30	3,530
40	6,000	6,000	12,000	9,600	20	30	4,510
310						TOTAL	$30,440
						ROUNDED	$31,000

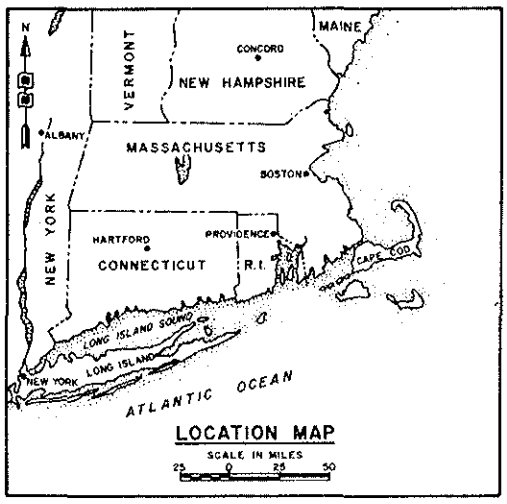
(1) ($16,000 - Total Costs)(Acres)(6%)

(2) After completion of protection project

(R 6/17/63)

CORPS OF ENGINEERS

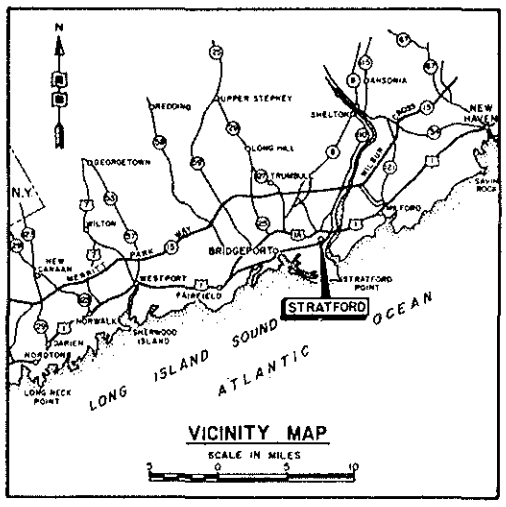
U.S. ARMY



LOCATION MAP

SCALE IN MILES

25 0 25 50



VICINITY MAP

SCALE IN MILES

3 0 3 10

LEGEND

FLOODED AREA 1954 HURRICANE

DAMAGE AREA OUTLINES

$ 1,531,000

TOTAL RECURRING 1954 TIDAL - FLOOD LOSSES AT 1962 PRICE LEVEL

SCALE IN FEET

1000 0 1000 2000

HURRICANE SURVEY

STRATFORD, CONNECTICUT

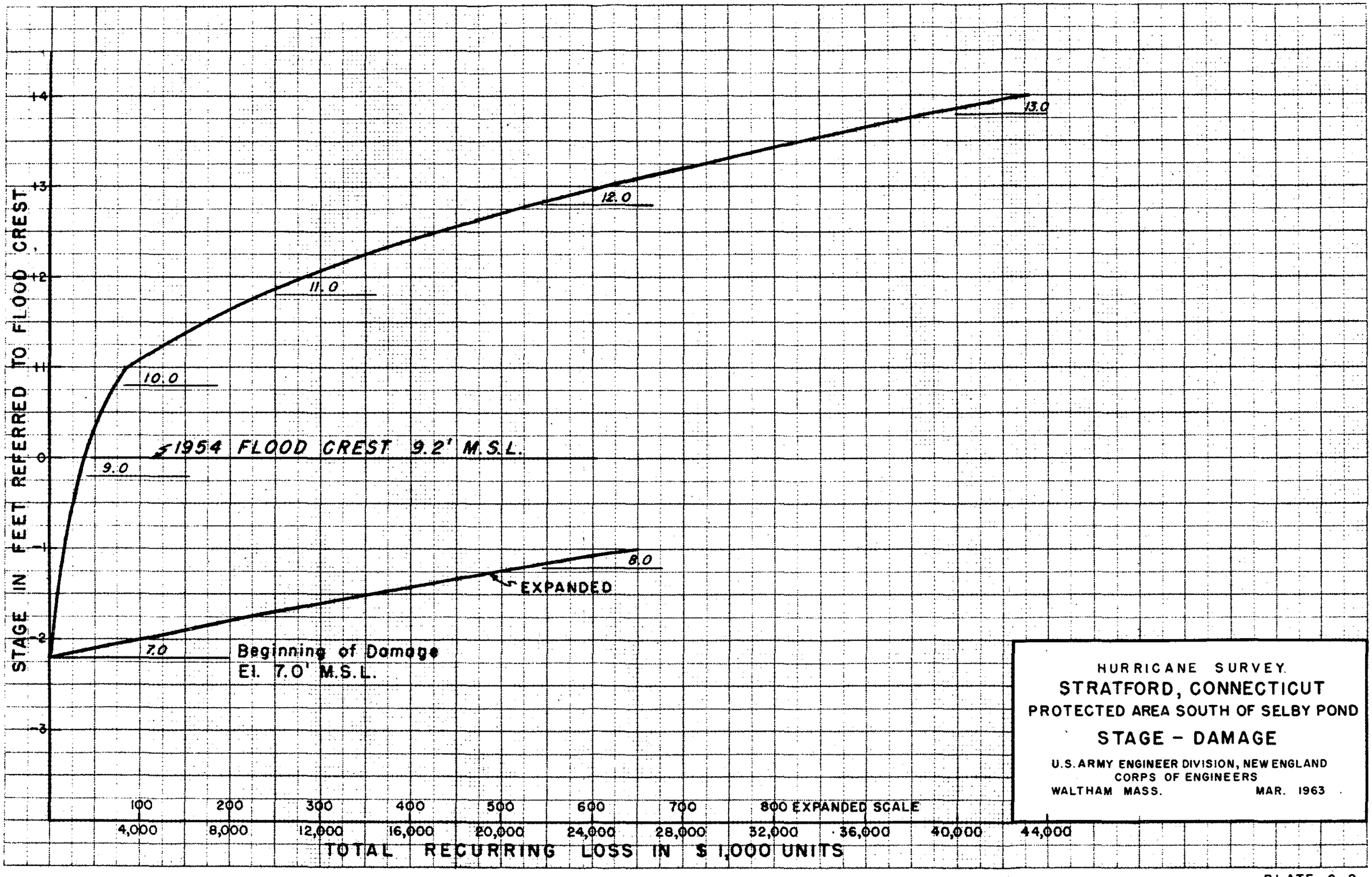
FLOOD AREA AND DAMAGES

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. FEB. 1963

SCALE AS SHOWN

PLATE C-1

PLATE C-1



HURRICANE SURVEY.

STRATFORD, CONNECTICUT

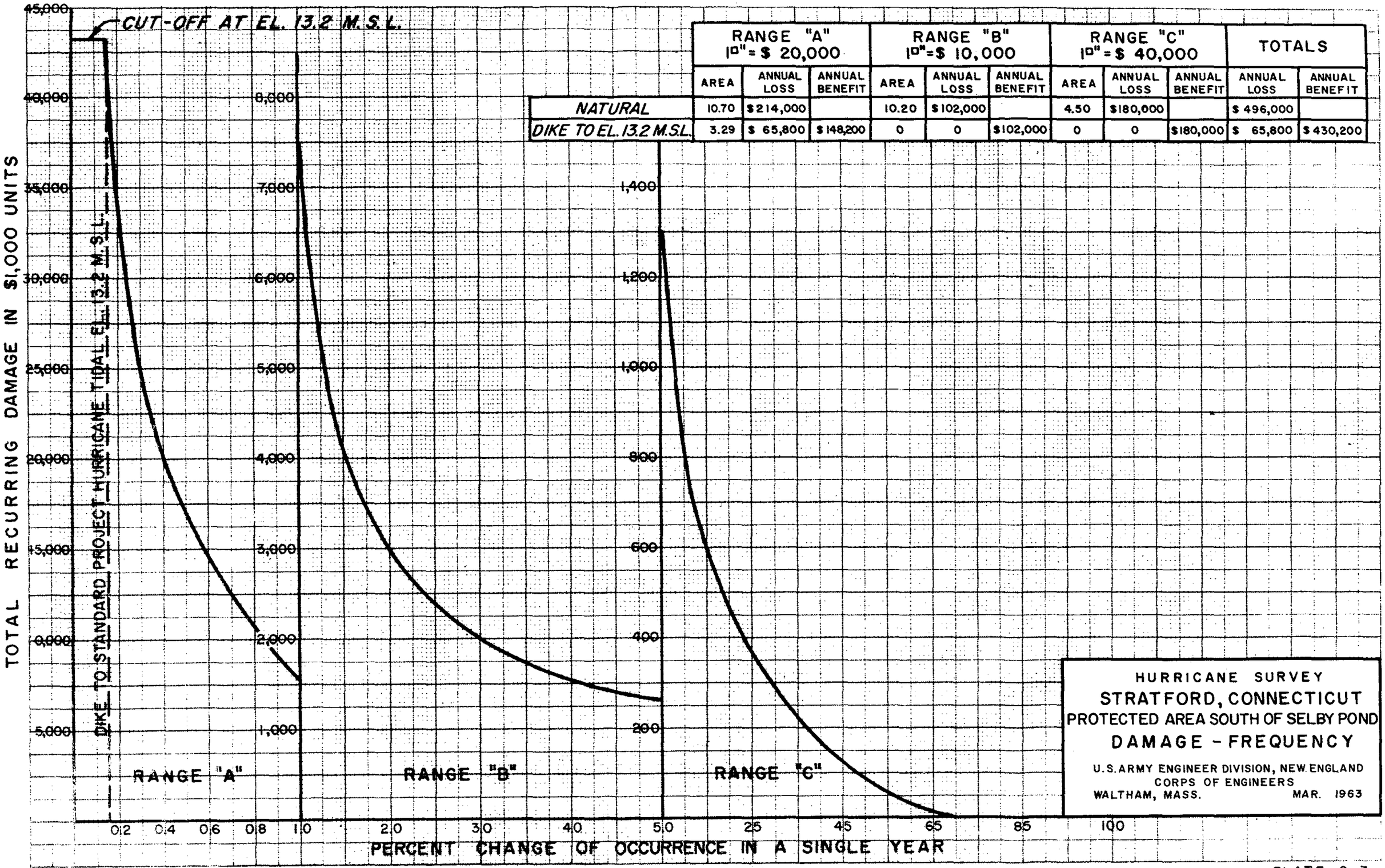
PROTECTED AREA SOUTH OF SELBY POND

STAGE - DAMAGE

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM MASS. MAR. 1963

PLATE C-2

	RANGE "A" 1" = $ 20,000			RANGE "B" 1" = $ 10,000			RANGE "C" 1" = $ 40,000			TOTALS	
	AREA	ANNUAL LOSS	ANNUAL BENEFIT	AREA	ANNUAL LOSS	ANNUAL BENEFIT	AREA	ANNUAL LOSS	ANNUAL BENEFIT	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL	10.70	$214,000		10.20	$102,000		4.50	$180,000		$ 496,000	
DIKE TO EL. 13.2 M.S.L.	3.29	$ 65,800	$148,200	0	0	$102,000	0	0	$180,000	$ 65,800	$ 430,200



HURRICANE SURVEY
STRATFORD, CONNECTICUT
PROTECTED AREA SOUTH OF SELBY POND
DAMAGE - FREQUENCY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAR. 1963

PLATE C-3

APPENDIX D

DESIGN STUDIES AND COST ESTIMATES

APPENDIX D

DESIGN AND COST ESTIMATES

TABLE OF CONTENTS

Paragraph	Title	Page
D-1	INTRODUCTION	D-1
D-2	DESIGN CRITERIA	D-1
	SELECTED PLAN OF PROTECTION	
D-3	Description of Plan	D-1
	a. General	D-1
	b. Great Meadows Protection	D-1
	c. Housatonic River Protection	D-3
	d. Pertinent Data	D-5
D-4	Site Geology and Foundation Conditions	D-8
	a. General	D-8
	b. Foundation Investigations	D-8
	c. Great Meadows Protection	D-9
	d. Housatonic River Protection	D-9
	e. Ferry Creek Pumping Station	D-10
D-5	Availability of Construction Materials	D-11
	a. Earth Fill	D-11
	b. Gravel	D-11
	c. Rock	D-11
	d. Concrete Aggregates	D-12
D-6	Selection of Embankment Sections	D-12
	a. General	D-12
	b. Foundation Preparation	D-12
	c. Embankments	D-12
D-7	Modification to Sewerage and Drainage Facilities	D-13
D-8	Lands and Damages	D-14
D-9	Relocations	D-14
D-10	Plan of Construction	D-15

APPENDIX D (Cont'd)

DESIGN AND COST ESTIMATES

Paragraph	Title	Page
	BASIS OF ESTIMATES OF FIRST COST AND ANNUAL COSTS	
D-11	Cost Estimates	D-15
D-12	Unit Prices	D-15
D-13	Contingencies, Engineering and Overhead	D-16
D-14	Local Contributions and Cooperation	D-16
D-15	Annual Costs	D-16
	FIRST COSTS AND ANNUAL CHARGES	
D-16	First Costs	D-16
D-17	Annual Charges	D-17

Number	TABLES	Page
D-1	Pertinent Data	D-6
D-2	Estimated First Costs	D-18
D-3	Estimated Annual Costs	D-22

PLATES

D-1	General Plan
D-2	Great Meadows Protection, Plan and Sections
D-3	Housatonic River Protection, Plan and Sections
D-4	Great Meadows Protection, Geology, Plan and Record of Explorations
D-5	Housatonic River Protection, Geology, Plan and Record of Explorations

APPENDIX D

DESIGN AND COST ESTIMATES

INTRODUCTION

D-1. This appendix presents design features and cost estimates for the selected plan of hurricane protection for Stratford, Connecticut. The principal features of the plan are shown on Plates D-1 through D-3.

The design and cost estimates for the selected plan are based on topographic and hydrographic surveys and subsurface explorations accomplished in 1962. The extent of subsurface investigations is covered in paragraph D-4.

DESIGN CRITERIA

D-2. The structures have been designed to withstand a design hurricane producing a stillwater elevation of 13.2 feet msl, accompanied by significant waves up to 8.0 feet high in the Great Meadows area, up to 5.0 feet high in the area north of Lordship and east of the airport, and up to 3.0 feet high along the west bank of the Housatonic River. In many locations the wave size becomes dependent on the ground elevation which, in turn, establishes the depth of water available to support a wave. Elevations varying from 14.0 to 18.0 feet msl were selected for the top of structures in order to provide protection against conditions of a design hurricane stillwater level and design waves.

SELECTED PLAN OF PROTECTION

D-3. DESCRIPTION OF PLAN

a. General. The selected plan of protection for Stratford, shown on Plates D-1, D-2, and D-3, consists of diking around the Great Meadows area of the town and protection inshore and along the west bank of the Housatonic River and the shoreline of Long Island Sound north of Stratford Point. The diking, in general, would be of earth-fill construction, faced with stone and/or seeded topsoil, with side slopes of 1 on 2.5.

b. Great Meadows Protection. The protection in this area of the town would start at high ground at the Surf Avenue ramp to the Connecticut Turnpike, about 1,000 feet east of the Bridgeport city line, and run in a general southerly direction

about 1,130 feet to beyond the south side of Great Meadows Road. It would consist of diking with a top width of 10 feet at an elevation of 14.0 feet msl. The dike would have rock on its top and seaward slope and seeded topsoil on its landward slope. A ramp would be constructed at the dike crossing of Great Meadows Road to bring the roadway up to the desired grade of protection.

The protection would continue in a southerly direction about 2,370 feet, along the east side of Buckley Brothers petroleum tank farm, to the bank of Johnsons Creek. This portion of the protection would consist of the enlargement or improvement of the existing sand-filled, fire protection dike at the tank farm by the addition of seeded topsoil to the top and both slopes of the dike and the placement of impervious fill where necessary to secure a minimum top width of 10 feet at an elevation of 14.0 feet msl. For approximately 1,000 feet of its length, where no additional fill is required to secure desired minimum dimensions, a gravel toe is provided on the landward side to prevent erosion from seepage at times of high tidal-flood stages.

The protection continues along the north and east banks of Johnsons Creek for about 1,600 feet and then along the north bank of Lewis Gut for a distance of 4,800 feet, a total of 6,400 feet, to a crossing of the Gut just east of the former breach through Long Beach into the Gut. The diking, for approximately 2,150 feet of its length along Johnsons Creek and at the mouth of Lewis Gut, would have rock on its top and seaward slope, seeded topsoil on its landward slope, and a 10-foot top width at an elevation of 14.5 feet msl. For a distance of about 50 feet, where the dike crosses a small tidal inlet, it would differ from the other diking in this area by having rock on both slopes and a top width of 12.0 feet. For the remaining 4,200 feet of its length along the north bank of the Gut the dike would be rock-faced and have a top width varying from 10 to 15 feet at an elevation of 15.5 feet msl. The landward slope along this length of the dike would contain a 25-foot wide berm at elevation 8.0 feet msl; the seaward slope, a 25-foot wide berm at elevation 8.0 feet msl, where waves up to 4.0 feet in height would be experienced, and a 50-foot wide berm at elevation 10.0 feet msl, where the waves would be greater than 4.0 feet in height.

The crossing of Lewis Gut is made by means of an earth-filled, rock-faced barrier, 1,230 feet long, with rock toes. It would have a top width of 16 feet at an elevation of 17.0 feet msl, a berm of varying width at an elevation of 6.5 feet msl, on the landward slope, and a 10-foot wide berm at elevation 8.5 feet msl, on the seaward slope. A conduit structure, containing six 6.0-foot diameter gated conduits, would be included in the barrier in order to permit the continued flow of the Gut through the barrier during normal periods.

The protection would be continued easterly, along the crest of Long Beach, for a distance of about 3,900 feet, to high ground at Lordship, by means of a dike with a top width of 21 feet, at elevation 18.0 feet msl, for the greater part of its length, reducing to a 10-foot width at elevation 16.0 feet msl, at its easterly end. This dike would be rock-faced throughout its entire length except for 200 feet at its eastern end where the landside slope would be surfaced with seeded topsoil. An access ramp to the top of the dike would be provided from the end of Oak Bluff Avenue. An existing gated culvert near the south end of Oak Bluff Avenue would be replaced with a new gated conduit.

c. Housatonic River Protection. This protection would start at high ground in the northern part of Lordship, about 1,300 feet south of the intersection of Main Street, Stratford Road, and Short Beach Road, and run easterly about 500 feet, then northerly about 1,100 feet, and then in a general westerly direction about 700 feet, over the present town dump. It would be located approximately 1,000 feet beyond the east end of the east-west runway (Runway 11-29) at the Bridgeport airport. It would then run northerly about 2,200 feet, across the head of the Marine Basin, to the west bank of the Housatonic River just below Air Force Plant No. 43 (the Avco Plant), a total distance of approximately 4,500 feet. The protection would consist of diking with a top width varying from 10 to 15 feet at elevations ranging from 15.5 to 18.0 feet msl. The top and both slopes of the dike would be rock surfaced with the exception of about 2,350 feet where the inner slope would be surfaced with seeded topsoil. Where the dike crosses the dump fill, material unsuitable for foundation would be excavated and spoiled.

The protection would continue along the bank of the river for a distance of about 2,500 feet, in a westerly direction. This portion of the protection would consist of improving the existing gravel and clay dike at the Avco Plant by raising its height approximately 4.0 feet, to an elevation of 16.5 feet msl, through the placement of additional fill. The modified dike would have stone on its top and seaward slope and seeded topsoil on its landward slope. It would retain its present top width of 12 feet and side slopes of 1 on 2.5 on the seaward side and 1 on 1.5 on the landward side. A 15-foot wide berm, at elevation 9.0 feet msl, would be included on the seaward side. The top of the dike would be paved as it would continue to be utilized as a patrol road.

From the west end of the Avco dike the protection continues north along the bank of the river, passing in front of the sewage treatment plant, to the south side of Birdseye Street, a distance of about 2,530 feet. It then runs about 200 feet to the west, crosses Birdseye Street, and ties into high ground about 740 feet to the north, at the south side of the knoll located between Birdseye Street and South Avenue. This latter protection, with the exception of 200 feet of concrete wall along the south side of Birdseye Street and approximately 960 feet of low diking with seeded topsoil on its top and both faces, would consist of diking with rock on its top and seaward slope and seeded topsoil on its landward slope. The diking would have a top width of 10 feet, for most of its length, at elevations ranging from 14.0 to 16.0 feet msl. For about 350 feet of its length, in front of the sewage treatment plant, the dike follows Beach Street, the road which affords access to the property south of the treatment plant. This portion of the dike would have a top width of 25 feet to accommodate Beach Street which would be elevated to the top of the dike.

To complete the protection along the Housatonic River requires (1) approximately 320 feet of dike, with rock on the top and riverside slope and seeded topsoil on the landward slope, across the tidal inlet on the south side of South Avenue, and (2) about 1,150 feet of rock-faced dike, with seeded topsoil on its landside slope, running north from high ground on the north side of Stratford Avenue, along the banks of the Housatonic River and Ferry Creek, to Broad Street. These latter two lengths of dike, totalling approximately 1,470 feet, would have a top width of 10 feet at an elevation of 15.5 feet msl. Closure from the upper end of the diking to high ground at Broad Street and Housatonic Avenue would be accomplished by 260 feet of low concrete wall along the south side of Broad Street.

Appurtenant structures and other miscellaneous work in connection with Housatonic River protection would include the following:

(1). Six ramps to bring roadway elevations up to the desired protection grade at the dike crossings of (a) Short Beach Road, (b) the unimproved road running from Main Street east to the shore, along the north side of the Marine Basin, (c) Sniffens Lane, (d) Beach Street, (e) Birdseye Street, and (f) Shore Road.

(2). Four pumping stations; one, with a capacity of 600 cfs, on the downstream side of Broad Street at Ferry Creek to handle the flow in the creek when river stages are high; one, with a capacity of 50 cfs, at the sewage treatment plant to discharge sewage effluent and interior drainage during flood periods; and two with a combined capacity of 220 cfs, at the Avco Plant to handle the interior drainage at this plant.

(3). Gated culverts at the dike crossings of (a) the drainage ditch entering at the head of the marine basin, east of the airport, (b) the tidal inlet on the south side of South Avenue, (c) the outlet from Selby Pond, and (4) the ditch draining low area on west side of Lockwood Avenue, south of Broad Street.

(4). Provisions for placing one foot of sandbagging across a private driveway running east from Elm Street, between Birdseye Street and Shore Road, and along the east side of East Main Street, north of the railroad, to prevent overflow from the Housatonic River to the protected area at times when flooding in the river is at or near the peak stage of 13.2 feet msl to be anticipated in a design hurricane.

d. Pertinent Data. Pertinent data on the selected plan of protection are summarized in Table D-1 on the following page.

TABLE D-1
PERTINENT DATA
HURRICANE PROTECTION PLAN
Stratford, Connecticut

Structure & Location	Type[1]	Length (feet)	Top Elev. (ft.msl)	Top Width (feet)	Ave. Height (feet)	Side Slopes
GREAT MEADOWS PROTECTION						
Diking						
Turnpike to Lewis Gut	A	2,680	14-14.5	10	8.5	1 on 2.5
	B	2,370	14	10(min)	6	1 on 2.5
	C	50	14.5	12	15	1 on 2.5
No.bank,Lewis Gut,includes crossing	A	600	14.5	10	8	1 on 2.5
	C	4,200	15.5	10-15	12	1 on 2.5[2]
	D	1,230	17	16	21	1 on 2.5[3]
Long Beach to Lordship	C	3,700	16-18	15-21	11	1 on 2.5
	A	200	16	10	6	1 on 2.5
HOUSATONIC RIVER PROTECTION						
Dikes and Walls						
Lordship to Housatonic R.	A	2,350	15.5-16.5	10	6	1 on 2.5
	C	2,150	16.5-18	15	10.5	1 on 2.5
At Avco Plant	A	2,500	16.5	12[4]	10	1 on 2.5[5]
	A	300	16	10	7	1 on 2.5
To Birdseye Street	A	1,830	16	10 & 25[6]	7	1 on 2.5[6]
	B	400	14	10	2	1 on 2.5
To South Ave.	E	200	15.5	-	8	-
	A	500	15.5	10	10	1 on 2.5
	B	560	15.5	10	2	1 on 2.5
To Broad St. at Housatonic Ave.	A	1,150	15.5	10	9	1 on 2.5
	F	260	15	-	4	

Pumping Stations

Location	Capacity	
Broad Street at Ferry Creek	600 cfs	
Sewage Treatment Plant	50 cfs	(includes 30 cfs for pumping effluent)
Air Force Plant 43 (Avco)		
No. 1	110 cfs	
No. 2	110 cfs	

TABLE D-1 (Cont'd)

NOTES:

(1) Following types pertain to respective structures:

A: Earth-filled dike, rock on top and outer face, seeded topsoil on inner face.

B: Earth-filled dike, seeded topsoil on top and both slopes.

C: Earth-filled dike, rock faced.

D: Earth-filled barrier, rock faced, with rock toes on both seaward and upstream side.

E: Concrete T-wall.

F: Sheet piling with concrete cap.

(2) With 25-foot wide berm at elevation 8.0 feet msl on landward side and 25-foot wide berm at elevation 10.0 feet msl on seaward side for 1,200 feet and 50-foot wide berm for 3,000 feet.

(3) With berm of varying width at elevation 6.5 feet msl on upstream side and berm of 10-foot width at elevation 8.5 feet msl on seaward side; side slopes of 1.0 on 1.5 on both sides below berms.

(4) Gravel roadway on top of dike for use by security patrol.

(5) With 15-foot wide berm at elevation 9.0 feet msl on riverside; slope of 1 on 1.5 on landward side.

(6) 15-foot wide pavement on top of dike, for 350 feet; with slope of 1 on 2 on landside.

D-4. SITE GEOLOGY AND FOUNDATION CONDITIONS

a. General. A winged headland, resembling a tombolo, projects into Long Island Sound from the west bank of the mainland at the mouth of the Housatonic River. It represents a fluvio-glacial terrace remnant, less than 25 feet above mean sea level, that has been flanked by wave action or flooding from the river and, as a result, is separated by marshes from the mainland. Sand bars project both west and north from its seaward extremity while, between these bars, the intervening marshes have been filled to accommodate the Bridgeport Airport and a large factory. The protection alignments lie on the terrace, bar, and marsh features and include a crossing of a shallow lagoon known as Lewis Gut. No bedrock is exposed at the site.

b. Foundation Investigations. Detailed geological reconnaissance of the site was supplemented with study of old maps showing former marsh areas and courses of tidal creeks. Considerable existing subsurface data was available from test borings made by private and municipal interests for various fill areas and structure locations. Type and distribution of subsurface explorations for the scope of this report have been based on the above study and available exploratory data with main consideration at this time to size and extent of proposed embankment structures. Explorations have consisted of four hand auger borings and 62 hand probings. The augar borings were made to determine the nature and thickness of fill materials and were extended below mean sea level by probings. The hand probings with sledge hammer assist were made to determine the presence of soft materials in certain areas as indicated by surficial geology and by courses of former tidal creeks. The results of these explorations and of pertinent and representative explorations by others are shown on Plates D-4 and D-5.

c. Great Meadows Protection. The proposed alignment of the Great Meadows Dike encloses a large tidal marsh area with a network of tidal streams known locally as the Great Meadows. The foundation soils along the entire dike alignment are variable silty sand and gravelly sand overlain, except at the extreme eastern end of the alignment, by surficial deposits of peat, muck and organic silts. In some reaches, these natural surficial deposits have been covered with man-made fills and natural beach bars. In general, the surficial deposits are composed of typical salt water marsh materials, generally fibrous, which vary in thickness from two to eight feet. Probings in the existing tidal streams indicate that the thicknesses of the soft surficial organic silt deposits are less than seven feet. Old maps indicate that former tidal streams crossed the Great Meadows at different locations. On the basis of limited exploration and local geology, it is expected that the deposits of soft organic silts are thick only at locations of former tidal streams.

In general, the marsh area at the western end of the project, where the dike alignment runs approximately north and south, has been filled hydraulically to a depth of from one to four feet. The fill material is variable but in general is silty medium to fine sand intermixed, in places, with small percentages of gravel and organic silt. In this area there is an existing dike, varying in height from three to ten feet along the east side of the Buckley Oil Company tank farm. This dike apparently is composed of materials from the hydraulic fill that has been placed in the area.

At the eastern end of the alignment, where it follows the shoreline of Long Beach for a distance of about 3,000 feet west of Lordship, the salt water marsh surface deposit of peat is covered with a beach bar composed of variable sand and gravel. In general, the beach bar has a maximum elevation of about 7.0 feet, msl, over the underlying peat. In 1962, sand fill was hydraulically placed on Long Beach with a view to (1) closing a former breach through the Long Beach sand bar, at the proposed location for the dike crossing of Lewis Gut, and (2) raising and widening the beach to secure a minimum top width of 75 feet at an elevation of 8.8 feet, msl, west of the former breach and 6.8 feet, msl, to the east. The organic silt deposit underlying the beach deposit is a very fibrous peat which, in places, is withstanding considerable wave action where exposed on the ocean side.

d. Housatonic River Protection. The alignment of the Housatonic River dike extends north from the area of the town dump, east of the Bridgeport Municipal Airport, to the bank of the Housatonic

River and then continues north along the bank of the river to high ground a short distance north of the mouth of Ferry Creek. The dike is intermittent with reaches extending across salt water marsh areas to higher portions of the natural terrace. The foundation soils along the entire alignment are variable silty sand and gravelly sand overlain, except in minor reaches, by surficial natural deposits of peat, muck, and organic silts which formed the original surface of the salt water marshes. In most reaches, these natural surficial deposits have been covered with man-made fills and earth dikes. In general, the surficial deposits are composed of typical salt water marsh materials, generally fibrous, up to six feet in thickness. This deposit is thicker in the vicinity of the marine basin, near the southern end of the alignment, and in the vicinity of Ferry Creek. Thicker deposits may also exist in other limited reaches. In the areas of these thicker deposits, the soil is mainly soft organic silt. Available data indicates that very soft organic silts exist in the Ferry Creek area to a depth of 40 feet.

In the town dump area, at the southern end of the alignment, man-made trash fill has been placed to a depth of about 10 feet. North of the dump, hydraulic fill has been placed in areas located along the shore between the marine basin and the sewage treatment plant at Birdseye and Beach Streets. This fill material, in general, varies from silty sand to clean gravelly sand but is principally a silty sand. It varies from one to six feet, mainly three to five feet, in thickness. The proposed protection at Air Force Plant 43 (the Avco Plant) will incorporate an existing earth dike. Soft organic silt occurs to depths varying from one to six feet along the water side toe of the Avco dike. North of the Avco dike, a small earth dike, about five feet high, has been constructed over the hydraulic fill in this area for a distance of over 1,000 feet along the shore. The materials in this dike are believed to be similar to the hydraulic fill material.

Fill material, consisting of a heterogeneous mixture of sand, gravel, flyash, coal, debris, and organics, has been placed to thicknesses up to five feet in depth in the areas along the bank of Ferry Creek, above its mouth.

e. Ferry Creek Pumping Station. The foundation soil at the site of the proposed pumping station on the downstream side of the Broad Street bridge over Ferry Creek is very soft organic silt to a depth of about 40 feet. A variable deposit of silty sand and gravelly sand underlies the soft organic silt deposit.

D-5. AVAILABILITY OF CONSTRUCTION MATERIALS

a. Earth Fill. Material suitable for the earth fill portions of the structures occur in natural overburden deposits in farm and wooded areas north of the residential area of Devon. Depending upon the final selected location, the haul distance from these deposits to the center of the project would be between four and eight miles.

b. Gravel. Approximately 120,000 cubic yards of coarse gravel are required for bedding purposes. The closest source of suitable bankrun gravel is in Seymour, Connecticut, at a haul distance of about 20 miles. Materials nearer to the site are very sandy and gravel sizes are small.

c. Rock. More then 200,000 cubic yards of rock are required for use as cover stone and in bedding and filter layers. Approximately 50,000 cubic yards of this rock requirement is in the one to two-ton size range. Nearly all marine construction along the Connecticut coast has utilized traprock from New York or the New Haven area, or granite from Westerly, Rhode Island. In general, the traprock is suitable for rockfills, bedding stone, and cover stone, for sizes under one-half ton, but presents a problem in the larger size ranges because of its brittleness and close jointing characteristics. Traprock sources with grading facilities are located in Branford, Wallingford, and Plainville, Connecticut, at haul distances of about 20, 30, and 40 miles, respectively, and in New York, 60 miles distant. The Westerly granite quarries are about 85 miles away. The traprock at Plainville is more massive than at Branford and it appears that required stone in the one-half ton range could be obtained here, on a selective set-aside basis to a modified quarrying operation. Minor quarrying of local gneiss formations has occured at Seymour, less than 20 miles northeast of Stratford, but the rock is of doubtful quality for marine usage. A quarry which could produce large size granite blocks of good quality lies to the east of New Haven, about 25 miles from the site. This is primarily a monumental quarry of great depth but of limited workability because of small opening. Existing waste piles could supply some of the requirements. This source, together with other monumental quarries lying between New Haven and Westerly could provide much of the larger stones but this manner of supply might not be competitive with trucking from Westerly or, possible, rail shipment from Barre, Vermont. It has been assumed, in the preparation of estimates for this report, that the haul distance for approximately three-fourths of the total rock requirements will be 20 miles, with the remainder being supplied from a distance of about 40 miles.

d. Concrete Aggregates. Concrete requirements are small and placement areas are spread throughout the project. It is assumed that transit-mix will be supplied from one of several such plants operating in the Bridgeport-Stratford area.

D-6. SELECTION OF EMBANKMENT SECTIONS

a. General. The embankment sections, shown on Plates D-2 and D-3, have been selected on the basis of the availability and economy of fill materials, construction considerations, foundation conditions, seepage control requirements, and the effect of wave action. All slope protection on the water side of the dikes consists of a layer or layers of rock over a layer of gravel bedding. The size of rock and the thicknesses of the rock layers have been determined as stated in WES Miscellaneous Paper No. 2-453, entitled, "Wave Forces on Rubble-Mound Breakwaters and Jetties."

b. Foundations Preparation. The selected dike sections do not require the removal of existing foundation soils in reaches covered with a significant amount of fill, earth dike, or beach material. The natural surficial deposits of peat, muck, and organic silt which have not been covered with man-made fill or beach materials will be stripped, except as otherwise noted in subparagraph "c"(2) below, in order to provide a stable embankment. The principal locations of such stripping are the water crossing of Lewis Gut and the portion of the diking between the town dump and the head of the marine basin.

c. Embankments.

(1) General. Excepting the greater portion of the Great Meadows protection along the north bank of Lewis Gut and the portion crossing the Gut from its north to its south bank, which are covered in subparagraphs (2) and (3), below, the dike embankments consist principally of compacted earth fill sections with rock slope protection on the water side and across the top to withstand the effect of waves. In some reaches, the earth fill section incorporates existing earth dikes. In reaches where overtopping is expected, rock slope protection is provided on the land side slopes. This land side slope protection also provides for the control of seepage through the foundation and embankment. Where the overtopping will not be significant, the embankment sections are provided with a seeded land-side slope. In these reaches, a pervious toe section has been incorporated to control foundation and embankment seepage where the dike is more than seven feet high. A foundation cut-off has been provided in the reach of dike crossing the town dump to aid in the control of foundation seepage.

(2) Dike on North Bank of Lewis Gut. For a distance of approximately 4,200 feet along the north bank of the Gut, west of the dike crossing of the Gut, the embankment section consists of compacted fill with rock facing plus the addition of a 25-foot wide berm on the seaward side for 1,200 feet, and a 50-foot wide berm for 3,000 feet, and a 25-foot wide berm on the land side. See Section C-C, Plate D-2. The surficial deposit along this alignment consists of an approximate five-foot thickness of peat and soft organic silt. In this reach, waves six to seven feet high are anticipated at the toe of the structure. This section was selected after studies showed that alternate sections, requiring the removal of the soft foundation soil, would be more costly. Berms about 25 feet wide are estimated to be necessary to insure stability. Studies indicated that a more economical section can be designed by widening the water side berm to 50 feet which results in reducing the wave height against the main portion of the dike to three feet. With this reduction in wave height, the height of the dikes, and the sizes and quantity of stone protection are less than if the berm has a width of 25 feet. The land side berm is considered adequate to control foundation seepage.

(3) Crossing of Lewis Gut. The embankment section selected for the crossing of Lewis Gut consists of a normal land dike section (rock cover on compacted fill) constructed on dumped earth fill, with a top elevation of 4.0 feet, msl, which is confined by two rock toes. See Section D-D, Plate D-2. This section permits construction with land equipment. Seepage through the base and foundation is controlled by the incorporation of gravel filter zones and providing a contact length between the dumped earth fill and the foundation soils that is equal to three times the hydraulic head differential based on a design still water level of 13.2 feet, msl.

D-7. MODIFICATIONS TO SEWERAGE AND DRAINAGE FACILITIES

The project will require a number of minor sewerage and drainage modifications, including the following:

a. Gating of the existing culverts and drainage lines at the intersection of Surf Avenue and Great Meadow Road and diverting the drainage so that all runoff on the seaward side of the protection in this area would drain to Johnsons Creek and all runoff on the landward side would drain to the east, along Great Meadows Road, to the upper end of Lewis Gut.

b. Modifying the present drainage system at Air Force Plant 43 by providing new pipe lines and manholes to conduct flows to the two proposed new pumping stations that would replace six present stations.

c. Relocation of the 10-inch force main running north along the west bank of the Housatonic River to the sewage treatment plant where necessary to keep it on the landward side of the protection, not under the dike.

d. Gating of the existing 36-inch effluent discharge line from the sewage treatment plant and providing for the bypassing of the effluent to a new pumping station during flood times.

e. Gating of the 30-inch drainage line running from East Main Street to the Housatonic River, north of the railroad.

All existing drainage lines which pass under the proposed dikes and walls would be strengthened or replaced where necessary in order to carry the additional weight to which they would be subjected. Some minor grading and additional catch basins, together with some ditching at landside toe of dikes, would be required. All existing and proposed drainage lines would be suitably gated to prevent the entry of tidal-flood waters. All conduits under the dikes would be sized to take a 100-year rainfall.

D-8. LANDS AND DAMAGES

The cost of furnishing necessary lands, easements, and rights-of-way, which would be one requirement of local cooperation, has been estimated on the basis of a field reconnaissance and the application of current market values for the locality. No lands would be acquired in fee. Permanent easements would be acquired on about 50 acres and temporary easements on 20 acres. Also, permanent flowage easements would be acquired on approximately 400 acres for the ponding of interior runoff and wave overtopping during hurricanes.

D-9. RELOCATIONS

The construction of the protection plan would not require the relocation of any highways or railroads. Construction of the proposed

ramps, at locations where the protection crosses present highways, would necessitate the relocation of a number of utility poles and about 1,200 feet of water mains.

D-10. PLAN OF CONSTRUCTION

The structures in the protection plan for Stratford would require about two years to construct. Dikes in low, exposed areas along Lewis Gut and Long Beach would be brought to grade as rapidly as possible, consistent with efficient construction procedures, to avoid loss of material in the event of a serious storm. The construction schedule would be generally as follows:

a. During the first year, the dike at Long Beach would be constructed and would provide access to the Lewis Gut crossing. The gated conduit at Lewis Gut would be completed. Also, modifications to the interior drainage system at Air Force Plant 43 and construction of the two new pumping stations at this plant would be completed. Work on the remaining dikes in the Great Meadows area and along the Housatonic River would be initiated.

b. During the second year, the pumping stations at the sewage treatment plant and at Ferry Creek would be constructed, and all remaining dikes, walls, and ramps would be completed, and the project placed in operation.

BASIS OF ESTIMATES OF FIRST COST AND ANNUAL COSTS

D-11. COST ESTIMATES

Estimates of quantities have been made on the basis of sections and details shown on Plates D-2 and D-3. Fill and rock quantities are "in place" measurements. The unit costs for fills include the costs of borrow, haul, and placement. Excavation costs include disposal of the material.

D-12. UNIT PRICES

Unit prices, which are on a 1962 price level, are based on averages for similar types of construction in New England, and where applicable, similar construction in other parts of the country. Adjustments have been made for the availability and locations of materials required, and the most likely methods of handling and placement. The adopted unit prices include allowances for items such as the improvement and restoration of

existing roads used for access during construction which do not appear as separate items in the cost estimate.

D-13. CONTINGENCIES, ENGINEERING AND OVERHEAD

The estimate includes a 15 percent allowance to cover contingencies. The costs for engineering, design, supervision, and administration, see Table D-2, are estimated lump sums based on experience on similar projects.

D-14. LOCAL CONTRIBUTIONS AND COOPERATION

It is proposed that local interests contribute in cash toward the first cost of the project an amount presently estimated at $1,285,000. This amount is equivalent to 25 percent of the first cost of the project less credit for furnishing lands, easements, and rights-of-way and accomplishing necessary modifications to sewerage and drainage facilities and relocations of utilities, see Table D-3.

D-15. ANNUAL COSTS

The estimate of annual charges is based on interest at 2.875 percent on both the Federal and non-Federal investments in the project and amortization of the investments over a period of 100 years. The total investment includes an item of interest during construction for one year (one-half of a total construction period of 2 years) at 2.875 percent. An allowance of $5,000 for the loss of taxes on lands is included in the annual cost. Costs of maintenance and operation of the project and major replacements are based on a knowledge of the site and costs of similar projects.

FIRST COSTS AND ANNUAL COSTS

D-16. FIRST COSTS

The estimated first cost of the protection plan is $6,200,000 of which $4,650,000 would be borne by the United States. Local interests would contribute in cash $1,285,000, accomplish all modifications to sewerage and drainage facilities at an estimated cost of $65,000 and all necessary relocations of utilities at an estimated cost of $25,000 and provide lands, easements and rights-of-way at an estimated cost of

*

$175,000 for a total local first cost of $1,550,000. Detailed breakdowns of the estimate, by principal features of the work, and by quantities and unit price, are shown in Table D-2. Allocations of costs are shown in Table D-3.

D-17. ANNUAL COSTS

The total annual charges for the Stratford protection plan amount to an estimated $218,000. Of this amount, $146,000 represents Federal annual charges and $72,000 non-Federal. The determination of annual charges is shown in Table D-3.

TABLE D-2

ESTIMATED FIRST COSTS
(1962 Price Level)

HURRICANE PROTECTION PLAN

Stratford, Connecticut

SUMMARY

Great Meadows Protection	$2,830,000
Housatonic River Protection	2,220,000
Subtotal	$5,050,000
Engineering and Design	450,000
Supervision and Administration	435,000
Subtotal	$5,935,000
Modifications to Sewerage and Drainage Facilities	65,000
Relocation of Utilities	25,000
Lands and Damages	175,000
Total First Cost	$6,200,000

Note: Preauthorization study costs in estimated amount of $50,000 not included in economic analysis.

(R 6/17/63)

TABLE D-2

ESTIMATED FIRST COSTS
(1962 Price Level)

HURRICANE PROTECTION PLAN

Stratford, Connecticut

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
Great Meadows Protection				
Preparation of site	1	job	L.S.	$ 2,500
Earth excavation, common	84,000	c.y.	.75	63,000
Earth fill, dumped	33,000	c.y.	1.35	44,500
Earth fill, compacted	150,000	c.y.	1.60	240,000
Gravel	92,000	c.y.	3.00	276,000
Rock fill	17,000	c.y.	7.00	119,000
Rock cover and bedding, under 1,000 lb.	122,000	c.y.	8.00	976,000
Rock cover, over 1,000 lb.	52,000	c.y.	10.00	520,000
Topsoil, seeded	4,600	c.y.	5.00	23,000
Pavement	5,000	s.y.	2.00	10,000
Guard rail	1,500	l.f.	2.00	3,000
Gated conduit at Lewis Gut	1	job	L.S.	175,000
Gated culvert near Oak Bluff Ave.	1	job	L.S.	10,000
	Subtotal			$2,462,000
Contingencies				368,000
Total - Great Meadows Protection				$2,830,000
Housatonic River Protection				
Preparation of site	1	job	L.S.	6,500
Earth excavation, common	52,000	c.y.	.75	39,000
Earth fill, dumped	10,000	c.y.	1.35	13,500
Earth fill, compacted	115,000	c.y.	1.60	184,000
Gravel	29,000	c.y.	3.00	87,000
Rock cover and bedding, under 1,000 lb.	38,000	c.y.	8.00	304,000
Topsoil, seeded	2,500	c.y.	5.00	12,500
Pavement	7,000	s.y.	5.00	35,000
Guard rail	2,500	l.f.	2.00	5,000
Concrete, reinf. walls	500	c.y.	75.00	37,500
Steel sheet pile(wall)	70	ton	300.00	21,000
Pumping Stations				
Avco No. 1 and appurtenant works	1	job	L.S.	225,000
Avco No. 2 and appurtenant works	1	job	L.S.	225,000
Sewage Treatment Plant	1	job	L.S.	90,000
Ferry Creek	1	job	L.S.	600,000

TABLE D-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
Housatonic River Protection (Cont'd)				
Gated Culverts				
at marine basin	1	job	L.S.	10,000
near South Avenue	1	job	L.S.	15,000
at Selby Pond	1	job	L.S.	10,000
at Lockwood Avenue	1	job	L.S.	10,000
		Subtotal		$1,930,000
Contingencies				290,000
Total - Housatonic River Protection				$2,220,000
Relocation of Utilities				
Relocation of utilities	1	job	L.S.	18,000
Contingencies				3,000
		Subtotal		$ 21,000
Engineering and design (local)				2,000
Supervision and administration (local)				2,000
Total - Relocations				$ 25,000
Modifications to Sewerage and Drainage Facilities				
Drainage at Surf Ave. and Great Meadows Road	1	job	L.S.	$ 15,000
Sanitary Sewer facilities	1	job	L.S.	20,000
Drainage at East Main St. north of railroad	1	job	L.S.	10,000
		Subtotal		$ 45,000
Contingencies				10,000
Engineering and design				5,000
Supervision and administration				5,000
Total - Modifications to Sewerage and Drainage Facilities				$ 65,000

TABLE D-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
		Lands and Damages		
Permanent easements	50	acres	L.S.	$ 90,000
Temporary easements	20	acres	L.S.	5,000
Permanent flowage easements	400	acres	L.S.	25,000
				$ 120,000
Contingencies				25,000
				145,000
Acquisition costs				30,000
Total Costs - Lands and Damages				$ 175,000

TABLE D-3

ESTIMATED ANNUAL COSTS
(1962 Price Level)

HURRICANE PROTECTION PLAN

Stratford, Connecticut

Federal Investment

First cost	$4,650,000(1)
Interest during construction	135,000
Total Federal Investment	$4,785,000

Federal Annual Costs

Interest on investment (2.875%)	$ 137,000
Amortization (0.18%)	9,000
	$ 146,000

Non-Federal Investment

Contributed funds	$1,285,000
Modifications to sewerage and drainage facilities	65,000
Relocations of utilities	25,000
Lands, easements, and rights-of-way	175,000
Total Non-Federal First Cost	$1,550,000(2)
Interest during construction	45,000
Total Non-Federal Investment	$1,595,000

(R 6/17/63)

TABLE D-3 (Cont'd)

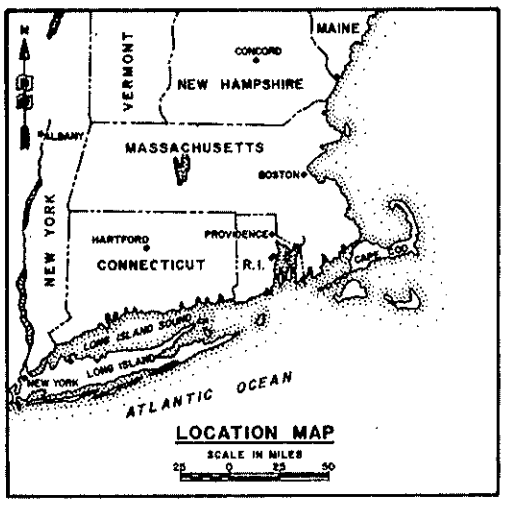
Non-Federal Annual Costs

Interest on investment (2.875%)		$ 46,000
Amortization (0.18%)		3,000
Major replacements		5,000
Maintenance and operation		
Salaries	10,000	
Embankment and general	5,000	
Concrete features	1,000	
Gates and accessories	2,000	18,000
Total Non-Federal Annual Costs		$ 72,000
Total Annual Costs		$218,000

(1) 75% of $6,200,000 First Cost
(2) 25% of $6,200,000 First Cost

Note: Preauthorization study costs in estimated amount of $50,000 not included in economic analysis.

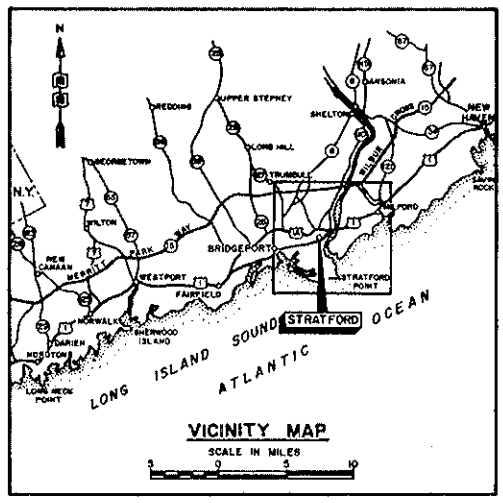
(R 6/17/63)



LOCATION MAP

SCALE IN MILES

25 0 25 50



VICINITY MAP

SCALE IN MILES

0 5 10

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
W.J.C.	F.L.C.	J.M.L.

PROJECT ENGINEER

CHIEF, HURRICANE SECTION

SUBMITTED BY: CHIEF, PLANS & APTS. BRANCH

APPROVED: CHIEF ENGINEERING DIV.

DATE: FEB. 1963

HURRICANE SURVEY

STRATFORD, CONNECTICUT

GENERAL PLAN

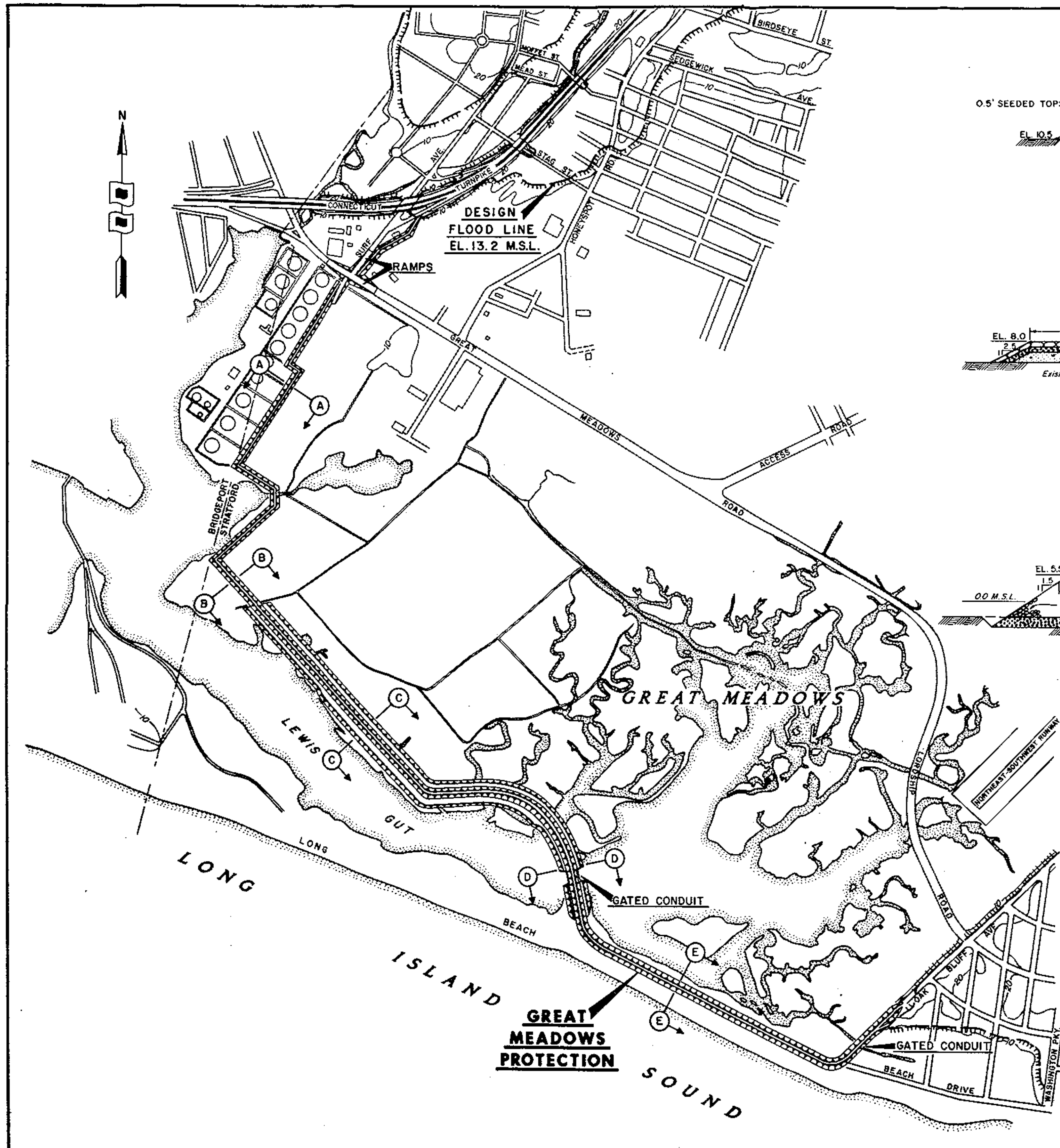
TO ACCOMPANY REPORT
DATED 22 MARCH 1963

SCALE:

DRAWING NUMBER
STR.-1-1000

SHEET

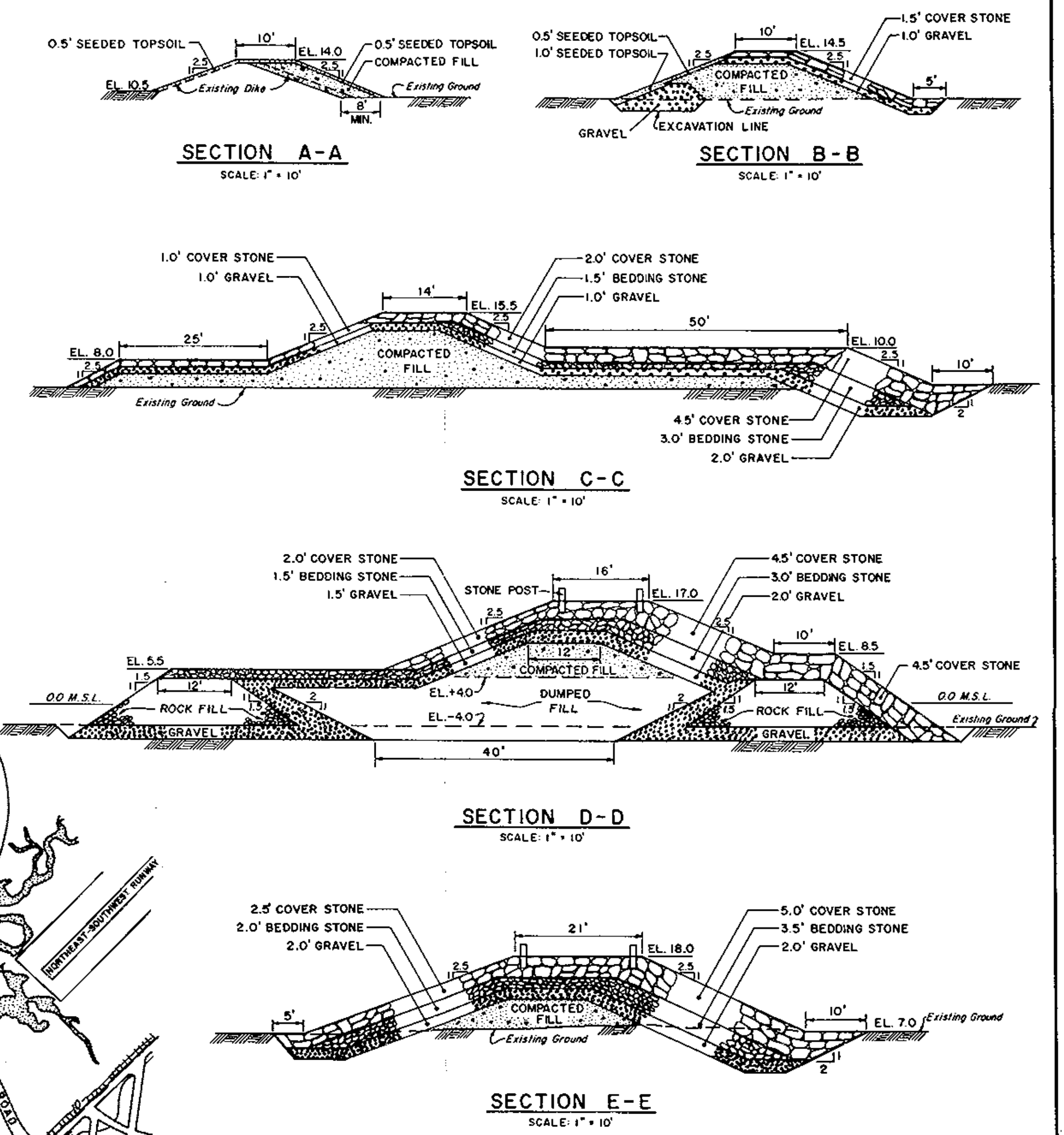
PLATE 1 & D-1



PLAN

SCALE IN FEET

500 0 500 1000



GRAPHIC SCALE

1" = 10'-0" 10' 0 10' 20'

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
H.H.G.	F.L.C.	J.M.L.

PROJECT ENGINEER

CHIEF, HURRICANE SECTION

SUBMITTED BY

CHIEF, PLANN & RPTS BRANCH

HURRICANE SURVEY
STRATFORD, CONNECTICUT
GREAT MEADOWS PROTECTION
PLAN & SECTIONS

APPROVED
CHIEF ENGINEERING DIV.

DATE FEB. 1963

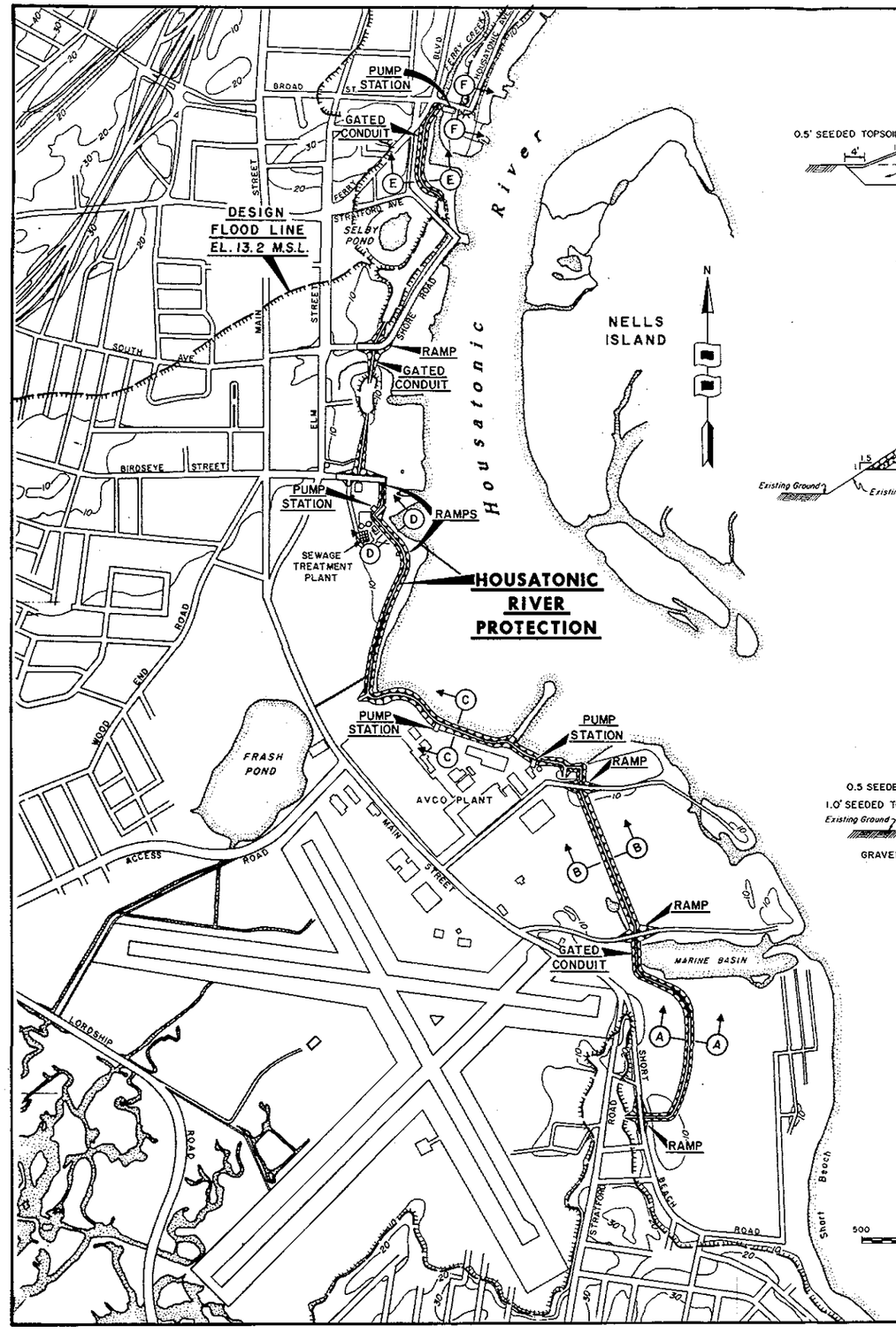
SCALE: AS SHOWN

DRAWING NUMBER
STR.-1-1003

SHEET

TO ACCOMPANY REPORT
DATED 22 MARCH 1963

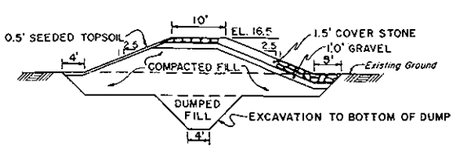
PLATE D-2



PLAN

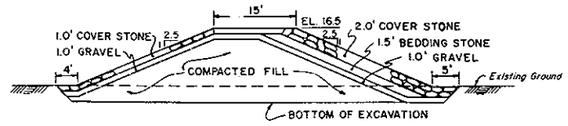
SCALE IN FEET

500 0 500 1000



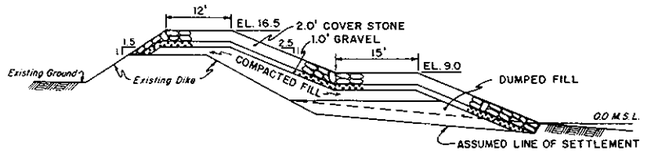
SECTION A-A

SCALE: 1" = 10'



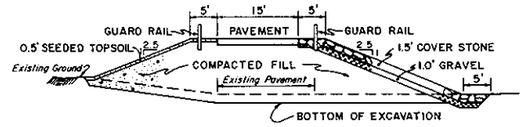
SECTION B-B

SCALE: 1" = 10'



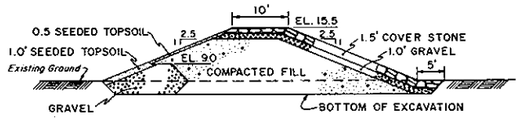
SECTION C-C

SCALE: 1" = 10'



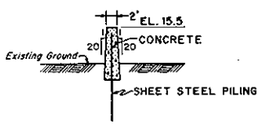
SECTION D-D

SCALE: 1" = 10'



SECTION E-E

SCALE: 1" = 10'



SECTION F-F

SCALE: 1" = 10'

GRAPHIC SCALE

1" = 10'-0" 0 10' 20'

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DR BY	TR BY	CK BY
H.M.G.	F.L.C.	J.M.L.

HURRICANE SURVEY
STRATFORD, CONNECTICUT
HOUSATONIC RIVER PROTECTION
PLAN & SECTIONS

PROJECT ENGINEER

CHIEF, HURRICANE SECTION

SUBMITTED BY

CHIEF, PLANS & RPTS BRANCH

APPROVED

CHIEF ENGINEERING DIV

DATE FEB. 1963

TO ACCOMPANY REPORT DATED 22 MARCH 1963

SCALE AS SHOWN

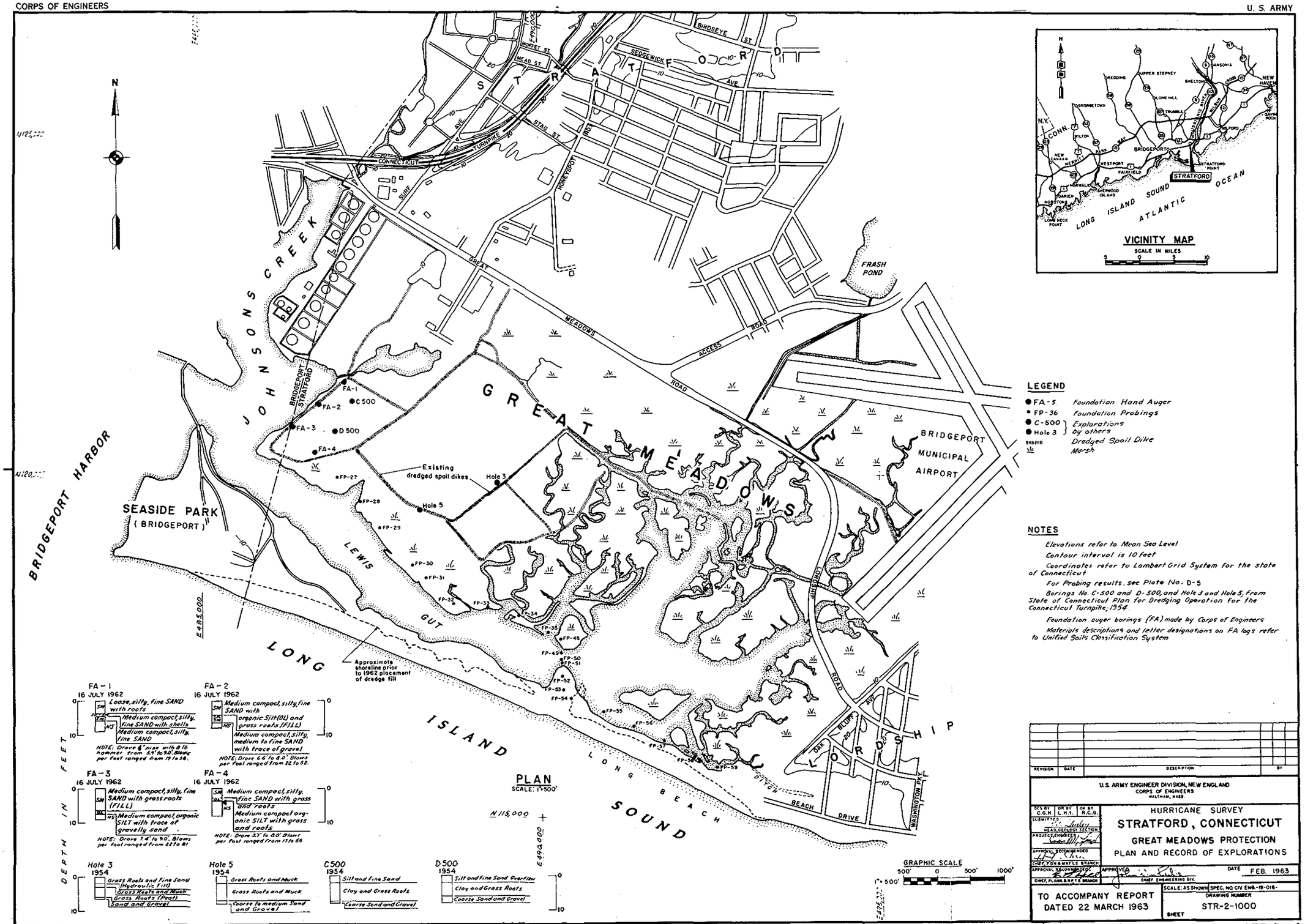
DRAWING NUMBER STR.-1-1004

SHEET

PLATE D-3

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

- ● FA-5. *Foundation Hand Auger*
- • FP-36 *Foundation Probings*
- ● C-500, ● Hole 3 } *Explorations by others*
- *Dredged Spoil Dike*
- *Marsh*

NOTES

Elevations refer to Mean Sea Level

Contour interval is 10 feet

Coordinates refer to Lambert Grid System for the state of Connecticut

For Probing results, see Plate No. D-5

Borings No. C-500 and D-500, and Hole 3 and Hole 5, from State of Connecticut Plan for Dredging Operation for the Connecticut Turnpike, 1954

Foundation auger borings (FA) made by Corps of Engineers

Materials descriptions and letter designations on FA logs refer to Unified Soils Classification System

DEPTH IN FEET

FA-1 — 16 JULY 1962
- 0–2: *Loose, silty, fine SAND with roots* (SM)
- 2–5: *Medium compact, silty, fine SAND with shells* (SM, WS)
- 5–10: *Medium compact, silty, fine SAND* (SM)

NOTE: Drove 6" rise with 8 lb hammer from 5.9" to 9.0". Blows per foot ranged from 19 to 38.

FA-2 — 16 JULY 1962
- 0–2: *Medium compact, silty, fine SAND with organic Silt (OL) and grass roots (FILL)* (SM, OL)
- 2–10: *Medium compact, silty, medium to fine SAND with trace of gravel* (SM)

NOTE: Drove 6.6" to 8.0". Blows per foot ranged from 22 to 52.

FA-3 — 16 JULY 1962
- 0–2: *Medium compact, silty, fine SAND with grass roots (FILL)* (SM)
- 2–10: *Medium compact, organic SILT with trace of gravelly sand* (OL, WS)

NOTE: Drove 7.4" to 9.0". Blows per foot ranged from 22 to 81.

FA-4 — 16 JULY 1962
- 0–2: *Medium compact, silty, fine SAND with grass and roots* (SM, OL)
- 2–10: *Medium compact organic SILT with grass and roots* (OL, WS)

NOTE: Drove 5.3" to 6.0". Blows per foot ranged from 17 to 56.

Hole 3 — 1954
- 0–2: *Grass Roots and Fine Sand (Hydraulic Fill)*
- 2–5: *Grass Roots and Muck*
- 5–8: *Grass Roots (Peat)*
- 8–10: *Sand and Gravel*

Hole 5 — 1954
- 0–2: *Grass Roots and Muck*
- 2–5: *Grass Roots and Muck*
- 5–10: *Coarse to medium Sand and Gravel*

C 500 — 1954
- 0–2: *Silt and Fine Sand*
- 2–5: *Clay and Grass Roots*
- 5–10: *Coarse Sand and Gravel*

D 500 — 1954
- 0–2: *Silt and Fine Sand, Over Fibre*
- 2–5: *Clay and Grass Roots*
- 5–10: *Coarse Sand and Gravel*

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
C.G.H.	L.H.I.	R.C.G.

SUBMITTED: HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED: CHIEF, FDN & MAT'LS BRANCH
APPROVAL RECOMMENDED: CHIEF, PLANNING & PTY'S BRANCH
APPROVED: CHIEF ENGINEERING DIV.

HURRICANE SURVEY
STRATFORD, CONNECTICUT
GREAT MEADOWS PROTECTION
PLAN AND RECORD OF EXPLORATIONS

DATE: FEB. 1963

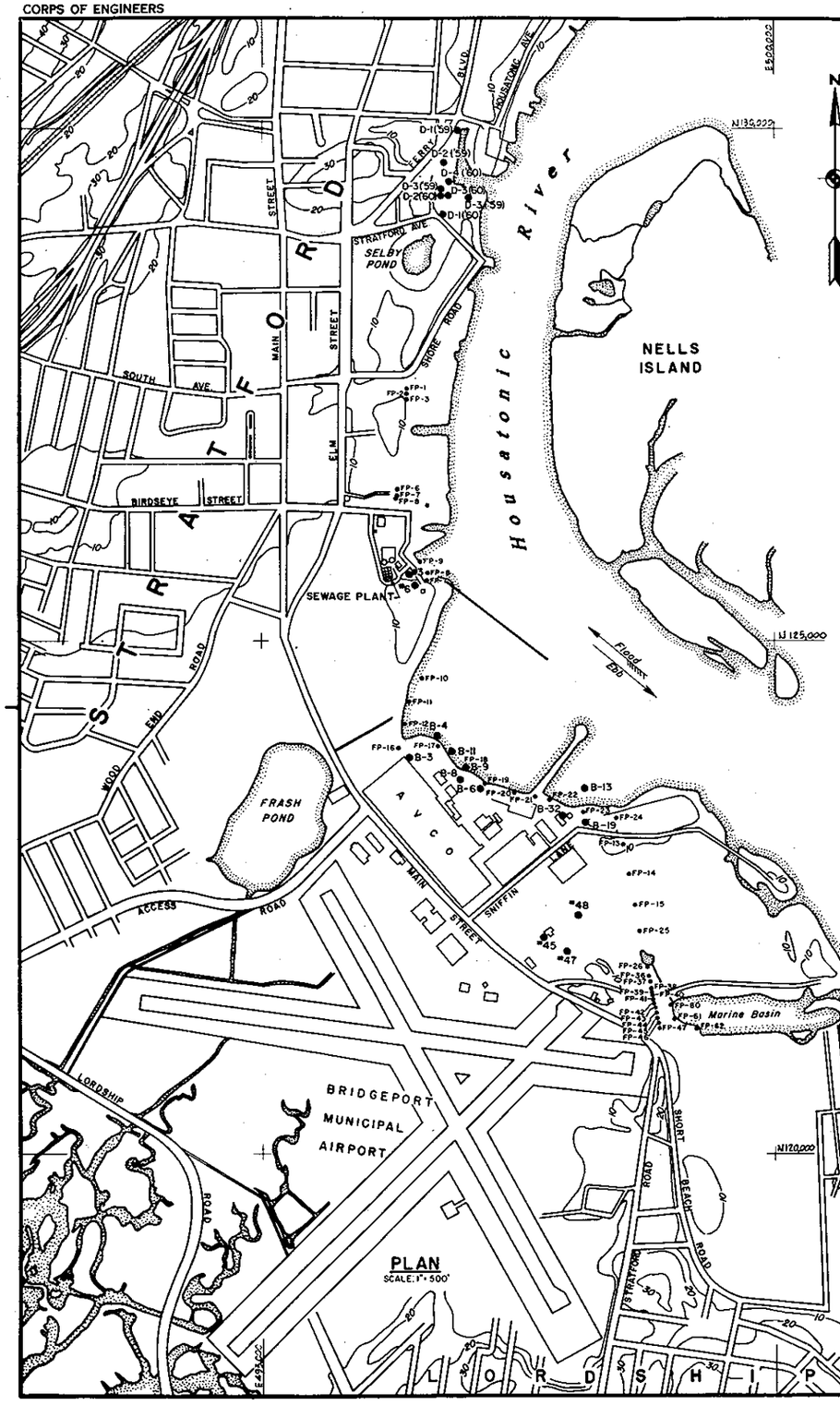
TO ACCOMPANY REPORT DATED 22 MARCH 1963

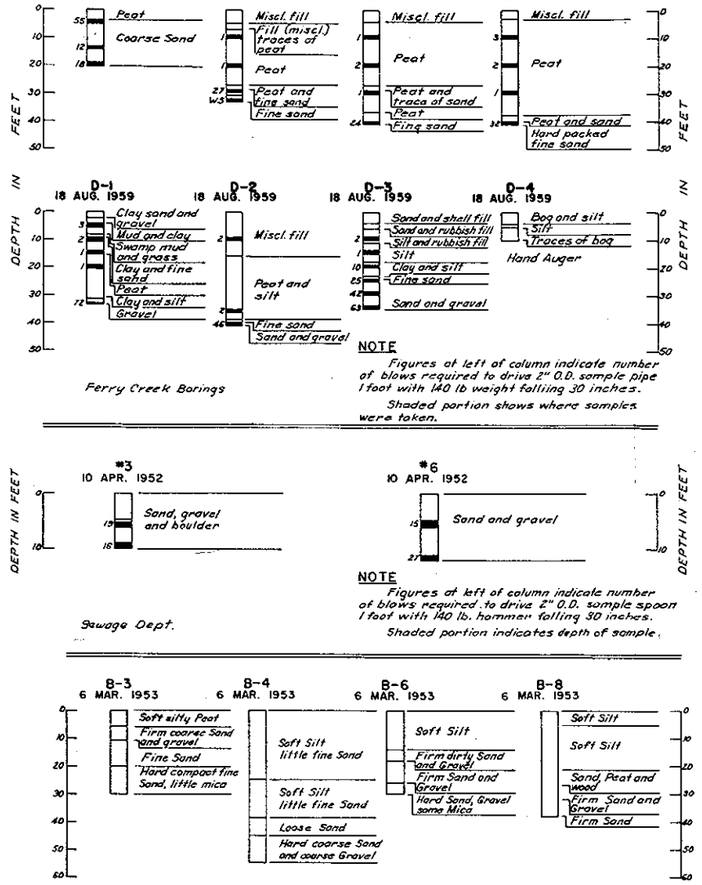
SCALE: AS SHOWN | SPEC. NO. CIV. ENG.-19-018-
DRAWING NUMBER: STR-2-1000
SHEET

PLATE D-4

CORPS OF ENGINEERS

U. S. ARMY





PROBING NUMBER	PENETRATION		
	WEIGHT OF 1 MAN	WEIGHT OF 2 MEN	DEPTHS AND BLOWS / FT REQ'D (8 LB HAMMER)
FP-1	0.0 - 0.6	-	0.6 - 1.5 9/4 100/6
FP-2	0.0 - 2.5	-	2.5 - 6.0 4/4 10 21 36
FP-3	0.0 - 1.0	-	1.0 - 2.0 100
FP-4	0.0 - 1.1	1.1 - 1.5	1.5 - 4.0 6/4 24 52
FP-5	0.0 - 1.0	1.0 - 1.5	1.5 - 4.0 4/4 20 35
FP-6	0.0 - 1.0	1.0 - 1.6	1.6 - 3.0 100/4 36
FP-7	0.0 - 0.5	0.5 - 0.7	0.7 - 1.0 8/5
FP-8	0.0 - 3.3	-	3.3 - 6.0 11/4 19 30
FP-9	0.0 - 2.0	2.0 - 3.7	3.7 - 5.0 100/4 31
FP-10	0.0 - 0.3	-	0.3 - 2.0 34/4 37
FP-11	0.0 - 0.4	-	0.4 - 3.0 9/4 33 51
FP-12	0.0 - 1.2	1.2 - 1.5	1.5 - 4.0 4/4 25 38
FP-13	0.0 - 0.3	0.3 - 0.5	0.5 - 3.0 100/4 29 35
FP-14	0.0 - 0.6	-	0.6 - 4.0 12/4 19 21 38
FP-15	0.0 - 0.6	-	0.6 - 2.0 100/4 38
FP-16	0.0 - 4.8	4.8 - 5.2	5.2 - 8.5 8/4 27 43 100/5
FP-17	0.0 - 3.6	3.6 - 5.6	5.6 - 6.6 46
FP-18	0.0 - 2.6	-	2.6 - 5.6 18 22 45
FP-19	0.0 - 4.8	-	4.8 - 5.8 44
FP-20	0.0 - 0.7	-	0.7 - 6.7 18 17 20 25 18 39
FP-21	-	-	0.0 - 5.2 11 6 11 17 36 100/4
FP-22	0.0 - 3.5	-	3.5 - 4.5 56
FP-23	0.0 - 1.4	1.4 - 2.1	2.1 - 3.6 39 100/4
FP-24	0.0 0.3	0.3 - 0.5	0.5 - 5.0 7/4 24 30 26 44
FP-25	0.0 - 2.2	2.2 - 3.2	3.2 - 5.0 100/4 57
FP-26	0.0 - 4.9	4.9 - 5.2	5.2 - 8.0 7/4 30 39
FP-27	0.0 - 5.2	5.2 - 5.6	5.6 - 7.0 100/4 60
FP-28	0.0 - 4.0	-	4.0 - 6.8 15/4 21 100/6
FP-29	0.0 - 4.0	-	4.0 - 9.0 10 18 19 42
FP-30	0.0 - 4.0	4.0 - 5.0	5.0 - 7.7 18 26 44/5
FP-31	0.0 - 4.8	4.8 - 5.2	5.2 - 7.0 100/4 51
FP-32	0.0 - 3.7	3.7 - 4.4	4.4 - 7.0 100/4 27 53
FP-33	0.0 - 1.7	1.7 - 1.9	1.9 - 4.2 4/4 28 46
FP-34	0.0 - 4.4	4.4 - 6.0	6.0 - 10.0 30 52
FP-35	0.0 - 4.6	4.6 - 6.8	6.8 - 8.0 8/4 42
FP-36	-	0.0 - 4.2	4.2 - 10.0 8/4 11 23 26 24 35
FP-37	0.0 - 4.5	-	4.5 - 5.0 100/4
FP-38	0.0 - 2.1	2.1 - 4.2	4.2 - 6.0 100/4 46
FP-39	-	-	0.0 - 0.5 100/4
FP-40	0.0 - 5.0	5.0 - 8.5	8.5 - 10.0 100/4 37
FP-41	0.0 - 5.7	5.7 - 12.0	12.0 - 13.0 63
FP-42	0.0 - 4.8	4.8 - 5.7	5.7 - 7.0 19/4 48
FP-43	0.0 - 4.6	4.6 - 5.0	5.0 - 6.0 45
FP-44	0.0 - 3.6	3.6 - 4.0	4.0 - 5.0 55
FP-45	-	0.0 - 0.2	0.2 - 1.5 100/4
FP-46	0.0 - 4.0	4.0 - 4.3	4.3 - 6.0 9/4 40
FP-47	-	0.0 - 0.2	0.2 - 1.7 34/4 69
FP-48	0.0 - 4.2	4.2 - 4.8	4.8 - 6.8 100/4 24 100/6
FP-49	0.0 - 1.0	-	1.0 - 3.0 26 51
FP-50	0.0 - 2.8	2.8 - 3.0	3.0 - 5.2 25 36 100/4
FP-51	-	-	0.0 - 4.4 11 15 25 34 65/4
FP-52	0.0 - 1.0	-	1.0 - 7.0 15 22 16 19 20 56
FP-53	0.0 - 0.8	-	0.8 - 3.0 100/4 23 37
FP-54	0.0 - 0.5	0.5 - 0.7	0.7 - 4.0 11/4 28 36
FP-55	0.0 - 0.5	-	0.5 - 4.0 100/4 10 18 41
FP-56	0.0 - 0.5	0.5 - 0.7	0.7 - 2.2 100/4 37 100/6
FP-57	0.0 - 3.1	3.1 - 3.5	3.5 - 6.0 34/4 29 39
FP-58	0.0 - 5.0	5.0 - 5.7	5.7 - 6.7 34/4 100/4
FP-59	0.0 - 4.8	4.8 - 5.1	5.1 - 5.9 100/4
FP-60	0.0 - 4.5	-	4.5 - 6.0 100/4 37
FP-61	0.0 - 1.8	1.8 - 2.0	2.0 - 4.0 29 44
FP-62	-	-	0.0 - 2.0 37 49

Probings made by 1 or 2 men pushing 3/4" pipe by hand and/or driving a 3/4" pipe with an 8 pound sledge hammer. Work performed by Corps of Engineers 7 - 19 July 1962.

Figures to right of slash indicate tenths of a foot penetration.

Borings are from various sources as indicated. Materials descriptions do not conform with the Unified Soils Classification System.

Elevations refer to Mean Sea Level

Contour interval is 10 feet

Coordinates refer to Lambert Grid System for the State of Connecticut.

For location of Probings No. FP-27 thru FP-35 and FP-49 thru FP-59 see Plate No. D-4

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY C.G.H. | DR. BY R.A.W. | CK. BY H.C.G.

SUBMITTED: K.C. Lasky, HEAD, GEOLOGY SECTION

PROJECT ENGINEER:

APPROVAL RECOMMENDED: CHIEF, ENGR'G BRANCH

APPROVAL RECOMMENDED: CHIEF, PLANS & SPEC'S BRANCH

HURRICANE SURVEY

STRATFORD, CONNECTICUT

HOUSATONIC RIVER PROTECTION

PLAN AND RECORD OF EXPLORATIONS

APPROVED: CHIEF ENGINEERING DIV.

DATE: FEB. 1963

TO ACCOMPANY REPORT DATED 22 MARCH 1963

SCALE: AS SHOWN | SPEC. NO. CIV. ENG.-18-018-

DRAWING NUMBER: STR-2-1001

SHEET

PLATE D - 5

APPENDIX E

LETTERS OF COMMENT AND CONCURRENCE

APPENDIX E

LETTERS OF COMMENT AND CONCURRENCE

Exhibit No.	Agency	Letter dated
E-1	State of Connecticut Water Resources Commission	4 February 1963
E-2	State of Connecticut Water Resources Commission	29 January 1963
E-3	Town of Stratford Office of Town Manager	18 January 1963
E-4	U.S. Department of Health, Education and Welfare; Public Health Service	24 January 1963
E-5	U.S. Department of the Interior Fish and Wildlife Service	7 June 1962
E-6	U.S. Department of the Interior Fish and Wildlife Service	3 July 1962

STATE OF CONNECTICUT
WATER RESOURCES COMMISSION
STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

February 4, 1963

Colonel P. C. Hyzer
Corps of Engineers, U. S. Army
New England Division
424 Trapelo Road
Waltham 54, Massachusetts

Re: Stratford Hurricane
Protection Project

Dear Colonel Hyzer:

This will refer to your letter of December 31, 1962 requesting the views concerning the requirements for meeting the local contributions necessary for carrying out this project.

You, no doubt, are aware that the State has adopted a policy of participating in local contributions required for federal projects when the State believes this is in the public interest.

We have discussed this matter with Stratford officials and in view of the State policy and based on past experience involving projects of a similar nature in other municipalities we believe that the local contribution required for this project will be met.

Very truly yours,

William S. Wise

William S. Wise
Director

WSW:js

EXHIBIT E-1

STATE OF CONNECTICUT
WATER RESOURCES COMMISSION
STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

January 29, 1963

Colonel P. C. Hyzer
Corps of Engineers, U. S. Army
New England Division
424 Trapelo Road
Waltham 54, Massachusetts

Re: Hurricane and Tidal Flood
Protection Project
Stratford, Connecticut

Dear Colonel Hyzer:

This will refer to your request of the views of this Commission concerning the adverse effects, if any, which the proposed project might have upon pollution of adjacent waters.

In our letter of August 31, 1962 we made certain assumptions regarding the layout and design of the protective works and certain suggestions as to pumping facilities needed to take care of the various wastes, both sanitary and industrial.

If these matters are resolved, we can see no reason why there should be any adverse effect upon the adjacent waterway.

Very truly yours,

William S. Wise

William S. Wise
Director

WSW:js

EXHIBIT E-2

TOWN OF STRATFORD

CONNECTICUT

OFFICE OF TOWN MANAGER

January 18th, 1963

Col. P. C. Hyzer
Division Engineer
U.S.Army Engineer Division
New England
424 Trapelo Road
Waltham, Mass.

Dear Colonel Hyzer:

I have received your letter of December 31, 1962 requesting my comments with respect to your proposed hurricane protectionplan for Stratford.

Expressions concerning the need and desire for protection against tidal flooding in Stratford were advanced by town officials and others at the public hearing that was held on January 23, 1962. The Town Council also indicated their support of a plan of dike protection for Stratford, if and when authorized by the Federal Government, by resolution adopted July 16, 1962.

I note that the plan proposed by you affords protection for the greater part of the town subject to tidal flooding. Moreover, construction of the project should serve to encourage future developments within the areas behind the proposed dikes.

It is my personal opinion, which is also shared by other town officials, that the requirements of local cooperation proposed by you would be met at the time construction of the project is undertaken.

Very truly yours,

Harry B. Flood

Harry B. Flood,
Town Manager

HBF:FCB

"COUNCIL-MANAGER GOVERNMENT SINCE 1921"

EXHIBIT E-3

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE
Region I
120 Boylston Street
Boston 16, Massachusetts

PUBLIC HEALTH SERVICE

January 24, 1963

Mr. John Wm. Leslie
Chief, Engineering Division
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Attention: Mr. P. Scott

Dear Mr. Leslie:

In answer to your inquiry concerning our statement on the adverse effect upon the pollution of wastes in the area of the Stratford, Connecticut Hurricane Protection Project, this has been discussed with Mr. William S. Wise, Director, Connecticut Water Resources Commission. We refer to our letter of October 8, 1962 and to Mr. Wise's letter of August 31, 1962. If in the construction of this project provisions are made to provide pumps of adequate capacity to handle the wastes to be discharged to the Housatonic River, this project would not have any adverse effects upon pollution of the waters of the area.

Sincerely yours,

Herbert H. Rogers

Herbert H. Rogers
Regional Program Director
Water Supply and Pollution Control
Public Health Service

EXHIBIT E-4

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 Temple Place
Boston 11, Massachusetts

June 7, 1962

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This letter constitutes our conservation and development report on plans for a hurricane tidal-flood protection project for Stratford, Connecticut. It was prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. et seq.), in cooperation with the Connecticut State Board of Fisheries and Game and the Connecticut Shell Fish Commission. The report has the concurrence of those agencies as indicated in their letters dated April 17, 1962 and April 23, 1962, respectively.

It is our understanding that construction of protective measures, affording protection to a major part of the Town of Stratford, can be accomplished by:

1. Construction of a dike running southerly from high ground near the intersection of Surf Avenue and the Connecticut Turnpike to a point approximately 500 feet south of the end of Honeyspot Road Extension. The dike is then to cross Great Meadows in a southeasterly direction and will cross the upper end of Lewis Gut to the east side of the present breach in Long Beach, then along Long Beach to high ground at the south end of Oak Bluff Avenue in the Lordship area of the town. Three gated conduits will be placed in the dike at Lewis Gut to permit normal drainage of Great Meadows area.

2. Construction of a series of dikes along the west bank of the Housatonic River from high ground near the intersection of Airway Drive and Stratford Road (on the east side of Stratford Road about 1,700 feet from its intersection with Main Street), passing about 1,000 feet inland of Sniffen's and Crimbo Points, to high ground at Housatonic Avenue.

The Great Meadows wetland is an important area for waterfowl. The significance of the area during the migration period is shown by an average daily use by approximately 1,500 black ducks. The average daily use of the area by wintering waterfowl is approximately 1,000 black ducks and 3,000 scaup ducks. Shorebirds utilize the area to a moderate degree.

EXHIBIT E-5

Oysters make up the important shellfish resources associated with the project. They are located in Lewis Gut and depend upon food and nutrients carried in a water circulation pattern from the Great Meadows area.

Encroachment and destruction of the wetlands have taken place on the Great Meadows area during the last several years. Hydraulic fill for development of oil storage facilities and industrial expansion has reduced the original wetland complex to one-half its size. However, the Great Meadows wetland area of 500 acres continues to contribute significantly to the maintenance of waterfowl and shellfish resources.

It is our understanding that fill material for dike construction will be obtained from inland borrow areas and the conduits will allow natural drainage of the basin. Lewis Gut is important as habitat for oyster resources and as wintering habitat for scaup ducks. Lewis Gut is in close proximity to project construction. We have determined that if the dike construction is located at least 4,000 feet easterly from the Bridgeport-Stratford town lines along Lewis Gut, as presently planned, the project will cause no significant damages to fish and wildlife resources. During construction, however, destructive changes may occur. Most serious would be an adverse change in marsh elevation and silting of considerable areas of marsh and open waters. Siltation is particularly likely in areas such as this where there is tidal action. Storms occurring during construction and prior to stabilization of the completed dike will cause washing and silting. This should be guarded against. Your specifications to the contractor who constructs the project should be those that will least disturb the marsh and should include safeguards against siltation of adjacent marsh and water. There appears to be no opportunity to include measures for fish and wildlife enhancement in the plans for this project; therefore, it is extremely important that the above precautions be observed.

We recommend--

1. That the dike be located at least 4,000 feet easterly from the Bridgeport-Stratford town lines along Lewis Gut.

2. That your specifications to the contractor should be those that will least disturb the marsh and should include all possible safeguards against siltation of adjacent marsh and water.

Sincerely yours,

James T. Horn
Acting Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON, MASSACHUSETTS

ADDRESS ONLY THE
REGIONAL DIRECTOR

NORTHEAST REGION
(REGION 5)
MAINE
NEW HAMPSHIRE
NEW YORK
VERMONT
PENNSYLVANIA
MASSACHUSETTS
NEW JERSEY
RHODE ISLAND
DELAWARE
CONNECTICUT
WEST VIRGINIA

July 3, 1962

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

Reference is made to your letter of May 24, 1962, informing us of a new dike alignment that is being considered with the hurricane protection plans for Stratford, Connecticut, and requesting our comments. This letter, prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), supplements our conservation and development report of June 7, 1962, for this project. It was prepared with the cooperation of the Connecticut State Board of Fisheries and Game and the Connecticut Shell Fish Commission. It has the concurrence of both these agencies as indicated in their letters dated June 18, 1962 and June 19, 1962, respectively.

We understand that the portion of the dike planned initially to extend in a southeasterly direction from a point near the intersection of Surf Avenue and the Connecticut Turnpike across the Great Meadows to the point where it would cross the upper end of Lewis Gut is being considered for realignment. This portion of the dike is now being planned to extend in a southerly direction from a point near the intersection of Surf Avenue and the Connecticut Turnpike to Lewis Gut and then along the north bank of Lewis Gut to the point where it crosses the upper end of Lewis Gut as in your previous plan. Gated conduits will be placed in the dike where it crosses Lewis Gut to permit normal drainage of the Great Meadows area.

We conclude that this new dike realignment will have no significant effects upon fish and wildlife resources provided the gated conduits contained in your original plans allow normal drainage of Great Meadows with the modified plan, and provided the Great Meadows area is not used to stockpile the materials that will be used for dike construction.

EXHIBIT E-6

We recommend--

1. That normal drainage of the Great Meadows area be accomplished by the gated conduits placed in the dike where it crosses Lewis Gut.

2. That no stockpiling of dike construction material be permitted on the Great Meadows area.

If no further modifications are made in your project plans we anticipate no additional studies by this Bureau. Should you find it necessary to modify the plans significantly, such as proposing a new realignment of the dikes, please advise us so that we can prepare another fish and wildlife report.

Sincerely yours,

John S. Gottschalk
Regional Director